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# Measurement of cavitation noise in ultrasonic baths and ultrasonic reactors

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Published by BSI Standards Limited 2019

ISBN 978 0 580 96577 7

ICS 17.140.01; 17.140.50

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 January 2019.

**Amendments/corrigenda issued since publication**

| Date | Text affected |
|---|---|

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# IEC TS 63001

Edition 1.0 2019-01

# TECHNICAL SPECIFICATION

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## Measurement of cavitation noise in ultrasonic baths and ultrasonic reactors

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 17.140.01; 17.140.50

ISBN 978-2-8322-6410-2

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CONTENTS

FOREWORD ..... 4
INTRODUCTION ..... 6
1 Scope ..... 7
2 Normative references ..... 7
3 Terms and definitions ..... 7
4 List of symbols ..... 11
5 Measurement equipment ..... 11
5.1 Hydrophone ..... 11
5.1.1 General ..... 11
5.1.2 Calibration of hydrophone sensitivity ..... 12
5.1.3 Hydrophone properties ..... 12
5.1.4 Hydrophone compatibility with environment ..... 12
5.2 Analyser ..... 13
5.2.1 General considerations ..... 13
5.2.2 Specific measurement method: transient cavitation spectrum at $f$ = 2,25$f_0$ ..... 14
5.2.3 Specific measurement method: broadband transient and stable cavitation spectra ..... 14
5.3 Requirements for equipment being characterized ..... 14
5.3.1 Temperature and chemistry compatibility with the hydrophone ..... 14
5.3.2 Electrical interference ..... 14
6 Measurement procedure ..... 14
6.1 Reference measurements ..... 14
6.1.1 Control of environmental conditions for reference measurements ..... 14
6.1.2 Measurement procedure for reference measurements ..... 15
6.2 Measurement procedures for in-situ monitoring measurements ..... 15
Annex A (informative) Background ..... 16
A.1 Cavitation in ultrasonic cleaning ..... 16
A.2 Practical considerations for measurements ..... 18
A.3 Measurement procedure in the ultrasonic bath ..... 19
A.4 Characterization methods that do not utilize the acoustic spectrum ..... 20
Annex B (normative) Cavitation measurement at 2,25$f_0$ ..... 21
B.1 General ..... 21
B.2 Measurement method ..... 21
Annex C (informative) Example of cavitation measurement at 2,25$f_0$ ..... 24
Annex D (normative) Cavitation measurement by extraction of broadband spectral components ..... 25
D.1 Compensation for extraneous noise ..... 25
D.2 Features of the acoustic pressure spectrum ..... 25
D.3 Identification of the operating frequency $f_0$ and direct field acoustic pressure ..... 26
D.3.1 Identification of the operating frequency $f_0$ ..... 26
D.3.2 Fit to primary peak (direct field) ..... 26
D.3.3 Determination of RMS direct field acoustic pressure ..... 26
D.3.4 Validation ..... 26
D.4 Identification of stable and transient cavitation component ..... 26
D.4.1 Subtraction of direct field component of spectrum ..... 26

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Document Sharing Hub

D.4.2 Determination of stable cavitation component ..... 26
D.4.3 Determination of transient cavitation component ..... 26
D.4.4 Validation ..... 27
Bibliography ..... 28

Figure A.1 – Typical setup of an ultrasonic cleaning device ..... 16
Figure A.2 – Spatial distribution of the acoustic pressure level in water in front of a 25 kHz transducer with reflections on all sides of the water bath (0,12 m × 0,3 m × 0,25 m) ..... 17
Figure A.3 – Typical Fourier spectrum for sinusoidal ultrasound excitation above the cavitation threshold at an operating frequency of 35 kHz ..... 17
Figure A.4 – Sketch of cavitation structure under the water surface at an operating frequency of 25 kHz ..... 18
Figure A.5 – Typical rectangular ultrasound signal with a frequency of 25 kHz and 50 Hz double half wave modulation ..... 19
Figure B.1 – Block diagram of the measuring method of the cavitation noise level $L_{\mathrm{CN}}$ ..... 22
Figure C.1 – Power dependency of the cavitation noise level $L_{\mathrm{CN}}$ ..... 24
Figure D.1 – Schematic representation of acoustic pressure spectrum $P_{\mathrm{RMS}}(f)$ ..... 25

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Document Sharing Hub
Full document details: PD IEC TS 63001:2019

INTERNATIONAL ELECTROTECHNICAL COMMISSION

# MEASUREMENT OF CAVITATION NOISE IN ULTRASONIC BATHS AND ULTRASONIC REACTORS

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Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

Technical Specification IEC 63001 has been prepared by IEC technical committee 87: Ultrasonics.

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The text of this Technical Specification is based on the following documents:

| Draft TS | Report on voting |
|---|---|
| 87/681/DTS | 87/693A/RVDTS |

Full information on the voting for the approval of this Technical Specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

Terms in **bold** in the text are defined in Clause 3.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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# INTRODUCTION

Ultrasonically induced **cavitation** is used frequently for immersion cleaning in liquids. There are two general classes of ultrasonically induced cavitation. **Transient cavitation** is the rapid collapse of bubbles. **Stable cavitation** refers to persistent pulsation of bubbles as a result of stimulation by an ultrasonic field. Both **transient cavitation** and **stable cavitation** may create significant localized streaming effects that contribute to cleaning. **Transient cavitation** additionally causes a localized shock wave that may contribute to cleaning and/or damage of parts. Both types of cavitation create acoustic signals which may be detected and measured with a **hydrophone**. This document provides techniques to measure and evaluate the degree of cavitation in support of validation efforts for ultrasonic cleaning tanks and cleaning equipment, as used, for example, for the purposes of industrial process control or for hospital sterilization.

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# MEASUREMENT OF CAVITATION NOISE IN ULTRASONIC BATHS AND ULTRASONIC REACTORS

## 1 Scope

This document, which is a Technical Specification, provides a technique of measurement and evaluation of ultrasound in liquids for use in cleaning devices and equipment. It specifies

- the cavitation measurement at 2,25$f_0$ in the frequency range 20 kHz to 150 kHz, and
- the cavitation measurement by extraction of broadband spectral components in the frequency range 10 kHz to 5 MHz.

This document covers the measurement and evaluation of the cavitation, but not its secondary effects (cleaning results, sonochemical effects, etc.).

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

**3.1**
**averaging time for cavitation measurement**
$t_{av}$
length of time over which a signal is averaged to produce a measurement of cavitation

Note 1 to entry: Averaging time for cavitation is expressed in seconds (s).

**3.2**
**cavitation**
formation of vapour cavities in a liquid

**3.2.1**
**transient cavitation**
**inertial cavitation**
sudden collapse of a bubble in a liquid in response to an externally applied acoustic field, such that an acoustic shock wave is created

**3.2.2**
**stable cavitation**
oscillation in size or shape of a bubble in a liquid in response to an externally applied acoustic field that is sustained over multiple cycles of the driving frequency

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**3.3**
**end of cable loaded sensitivity**
$M_{\mathrm{L}}(f)$
<of a **hydrophone** or **hydrophone assembly**> modulus quotient of the Fourier transformed output **voltage** $U(f)$ at the end of any integral cable or output connector of a **hydrophone** or **hydrophone-assembly**, when connected to a specific electric load impedance, to the Fourier transformed acoustic pressure $P(f)$ in the undisturbed free field of a plane wave in the position of the reference centre of the **hydrophone** if the **hydrophone** were removed, at a specified frequency

Note 1 to entry: The Fourier transform is in general a complex-valued quantity but for this document only the modulus is considered, and is expressed in volt per pascal, V/Pa,

Note 2 to entry: The term 'response' is sometimes used instead of 'sensitivity'.

**3.4**
**end of cable loaded sensitivity level**
$M_{\mathrm{L.dB}}$
twenty times the logarithm to the base 10 of the ratio of the modulus of the **end of cable loaded sensitivity** $M_{\mathrm{L}}(f)$ to a reference sensitivity of $M_{\mathrm{ref}}$.

Note 1 to entry: $M_{\mathrm{L,dB}} = 20\log_{10}\frac{|M_{\mathrm{L}}|}{M_{\mathrm{ref}}}$ dB .

Note 2 to entry: The value of reference sensitivity $M_{\mathrm{ref}}$ is 1 V/Pa.

**3.5**
**hydrophone**
transducer that produces electric signals in response to waterborne acoustic signals

[SOURCE: IEC 60050-801:1994, 801-32-26] [1]

**3.6**
**hydrophone assembly**
combination of **hydrophone** and **hydrophone pre-amplifier**

[SOURCE: IEC 62127-3: 2007, 3.10] [2]

**3.7**
**number of averages**
$N_{\mathrm{av}}$
number of waveforms captured and averaged in a **cavitation** measurement

**3.8**
**operating volume**
part of the liquid volume where cavitation effects are intended

**3.9**
**operating frequency**
$f_0$
driving frequency of ultrasound generator

Note 1 to entry: Operating frequency is expressed in hertz (Hz).

**3.10**
**relative cavitation measurements**
measurements made for purposes of comparison between two different cleaning environments or different locations within a cleaning environment, such that the **end-of-cable loaded sensitivity** of the **hydrophone** may be assumed to be identical in both cases

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