

# TECHNICAL SPECIFICATION



**Ultrasonics – Real-time pulse-echo scanners – Phantom with cylindrical, artificial cysts in tissue-mimicking material and method for evaluation and periodic testing of 3D-distributions of void-detectability ratio (VDR)**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2011 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland  
Email: [inmail@iec.ch](mailto:inmail@iec.ch)  
Web: [www.iec.ch](http://www.iec.ch)

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: [www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: [www.iec.ch/webstore/custserv](http://www.iec.ch/webstore/custserv)

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: [csc@iec.ch](mailto:csc@iec.ch)  
Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00

# TECHNICAL SPECIFICATION



---

**Ultrasonics – Real-time pulse-echo scanners – Phantom with cylindrical, artificial cysts in tissue-mimicking material and method for evaluation and periodic testing of 3D-distributions of void-detectability ratio (VDR)**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

PRICE CODE

---

ICS 17.140.50

ISBN 978-2-88912-377-3

## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references.....	7
3 Terms and definitions.....	7
4 Symbols.....	11
5 Ambient conditions of measurement with the phantom.....	12
6 Specification of TMM 3D artificial anechoic-cyst phantom.....	12
6.1 3D-phantom concept.....	12
6.2 General phantom specification.....	12
6.3 TMM specifications:.....	12
6.4 Anechoic targets.....	13
6.5 Phantom enclosure.....	13
6.6 Scanning surface:.....	13
6.7 Dimensions.....	13
6.8 Phantom stability.....	14
6.9 Digitized image data.....	14
7 Principle of measurement using the 3D anechoic void phantom.....	15
7.1 General.....	15
7.2 Analysis.....	15
Annex A (informative) Description of construction of an example phantom and test results.....	17
Annex B (informative) System description.....	37
Annex C (informative) Rationale.....	38
Annex D (informative) Uniformity measurement.....	41
Bibliography.....	48
Figure A.1 – Example of measurement test equipment.....	17
Figure A.2a) – Package of TMM slices containing alternating void slices and attenuation slices of polyurethane foam.....	19
Figure A.2b) – Holes of different diameters in the void slices allow the use of the phantom with different ultrasound frequencies (1 – 15 MHz).....	19
Figure A.2 – TMM slices.....	19
Figure A.3 – Structure of foam.....	19
Figure A.4 – C-images of voids.....	20
Figure A.5 – Experimental confirmation of Rayleigh distribution with attenuating TMM.....	21
Figure A.6 – Speed of sound in saltwater.....	22
Figure A.7 – Phantom with motor drive and two types of adapters.....	22
Figure A.8 – B-, D-, C- images and grey scale.....	24
Figure A.9 – Illustration of the VDR calculation for a ROI consisting of a single line.....	25
Figure A.10 – B-C-D planes.....	26
Figure A.11 – Principle of the ultrasound scanning array and beam.....	27
Figure A.12 – Schematic of B-D-C planes.....	28

Figure A.13 – 3D-Phantom images .....	29
Figure A.14 – B-D-C images and VDR .....	30
Figure A.15a) – Example: Curved Array, 40-mm radius, 3,5MHz with good VDR-values.....	31
Figure A.15b) – Example: Curved Array, 40-mm radius, 3,5MHz with poor VDR-values .....	31
Figure A.15 – VDR-values .....	31
Figure A.16 – Example: Linear array transducer 13 MHz.....	32
Figure A.17 – Interpretation of VDR parameter .....	33
Figure A.18 – Explanation of saturation (0-255 grey-scale range) .....	34
Figure A.19a) – Voids 2,5 mm.....	35
Figure A.19b) – Voids 3,0 mm.....	35
Figure A.19c) – Voids 4 ;0 mm.....	35
Figure A.19 – Saturation effect .....	35
Figure A.20 – Void spot analysis.....	35
Figure A.21a) – Local dynamic curve .....	36
Figure A.21b) – Expected envelope of VDR .....	36
Figure 21 – Local dynamic range .....	36
Figure C.1 – Autocorrelation function.....	39
Figure C.2a) – Autocorrelation function at 4,06 cm depth.....	40
Figure C.2b) – Autocorrelation function at 9,08 cm depth.....	40
Figure C.2 – Autocorrelation function – dependence on depth .....	40
Figure C.3 – Autocorrelation function at 10,94 cm depth.....	40
Figure D.1a) – Uniformity test with related linear or curved array transducer.....	42
Figure D.1b) – Fixed pattern in B-image .....	42
Figure D.1 – Uniformity test .....	42
Figure D.2a) – B-D-C image and fixed pattern in C-image.....	43
Figure D.2b) – Grey scale display of full array .....	43
Figure D.2 – Uniformity test – Additional features .....	43
Figure D.3 – Linear transducer with reference tape.....	44
Figure D.4 – Interpretation of simulated transducer failure when half of the probe is covered by five layers of 50-mm fabric tape.....	45
Figure D.5 – Disconnected elements, example with linear transducer .....	46
Figure D.6 – Example with curved array transducer and reference tape.....	47

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**ULTRASONICS – REAL-TIME PULSE-ECHO SCANNERS –  
PHANTOM WITH CYLINDRICAL, ARTIFICIAL CYSTS IN TISSUE-MIMICKING  
MATERIAL AND METHOD FOR EVALUATION AND PERIODIC TESTING  
OF 3D-DISTRIBUTIONS OF VOID-DETECTABILITY RATIO (VDR)**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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

IEC 62558, which is a technical specification, has been prepared by IEC technical committee 87: Ultrasonics.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
87/434/DTS	87/458/RVC

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

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

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

A bilingual version of this publication may be issued at a later date.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## INTRODUCTION

This technical specification provides an example of a measurement method and of a test phantom. The specified method and test equipment permit operation without knowledge of proprietary information of the diagnostic ultrasonic equipment manufacturer.

This technical specification describes desirable specifications and performance characteristics of a tissue-mimicking material (TMM) 3D artificial-cyst phantom. An example including design of a realized and conforming phantom is given. The described results are independent of applied electronic and design architecture of diagnostic ultrasound systems and related transducers suitable for testing with the phantom.

Medical diagnostic ultrasound systems and related transducers need periodic testing as the quality of medical decisions based on ultrasonic images may decrease over time due to progressive degradation of essential systems characteristics. The TMM phantom is intended to be used to measure and to enable documentation of changes in void-detectability ratio in periodic tests over years of use.

The example of phantom design uses sliced TMM arranged as alternating "cyst-slices" and "attenuation-slices". It allows measurement along all three axes of the ultrasonic beam (axial, azimuthal and elevation) to determine the void-detectability ratio depending on the depth in the image generated from a transducer. The basis of the design concept and measurement method is anechoic, artificial cysts, representing idealized pancreatic ducts in the human body, and the measurement of the void-detectability ratio inside the images of these artificial cysts. The images of the artificial cysts should appear anechoic. The measurement of void-detectability ratio quantifies the diagnostic ultrasound system's ability to properly represent these objects. Increased artifactual signals appearing within images of these artificial cysts indicate a degradation of certain image parameters. A certain level of artifactual signals is to be expected for any ultrasound system, due to the emitted beam's shape and the transducer's receive characteristics. Any increase in these artifactual signals may be caused, for example, by grating- and side-lobes that may occur due to, for example, partial or total depolarisation of elements, delamination between transducer elements and lens, or corrosion. The measurement procedure allows a reliably and reproducible determination of the visibility limits of small voids, an important image parameter of an ultrasound diagnostic system over the time of use, by applying dedicated acquisition, processing and documentation software.

Four informative annexes are provided: Annex A – Description of construction of an example phantom and test results; Annex B – System description; Annex C – Rationale; Annex D – Uniformity measurement.



# ULTRASONICS – REAL-TIME PULSE-ECHO SCANNERS – PHANTOM WITH CYLINDRICAL, ARTIFICIAL CYSTS IN TISSUE-MIMICKING MATERIAL AND METHOD FOR EVALUATION AND PERIODIC TESTING OF 3D-DISTRIBUTIONS OF VOID-DETECTABILITY RATIO (VDR)

## 1 Scope

This technical specification specifies essential characteristics of a phantom and method for the measurement of void-detectability ratio for medical ultrasound systems and related transducers. It is restricted to the aspect of long-term reproducibility of testing results.

This technical specification establishes:

- important characteristics and requirements for a TMM 3D artificial cyst phantom using anechoic voids;
- a design example of a 3D artificial cyst phantom, the necessary test equipment and use of relevant computer software algorithms.

This technical specification is currently applicable for linear array transducers. A uniformity test prior to void-detectability ratio (VDR) measurement is recommended.

NOTE The basic concept of the 3D artificial-cyst phantom may also be valid for other types of ultrasound transducers; however there is a need for further verification (see Annex D).

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including amendments) applies.

IEC 60050-802, *International Electrotechnical Vocabulary, Part 802: Ultrasonics*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions contained in IEC 60050-802 as well as the following terms and definitions apply.

### 3.1

#### **acoustic coupling medium**

medium, usually fluid or a gel, that allows echo-free coupling of the transducer to the coupling window of the phantom.

### 3.2

#### **artifactual signal**

signal at a specific region in an image where no signal is expected (e.g. inside the image of a void)

### 3.3

#### **attenuation coefficient**

at a specified frequency, the fractional decrease in plane wave amplitude per unit path length in the medium, specified for one-way propagation