

# INTERNATIONAL STANDARD



**Printed electronics –  
Part 402-3: Printability – Measurement of qualities – Voids in printed pattern  
using a two-dimensional optical image**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2021 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.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### 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 corrigendum or an amendment might have been published.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

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 It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

#### IEC online collection - [oc.iec.ch](http://oc.iec.ch)

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

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

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Preview generated by EVS

# INTERNATIONAL STANDARD



**Printed electronics –  
Part 402-3: Printability – Measurement of qualities – Voids in printed pattern  
using a two-dimensional optical image**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 31.180

ISBN 978-2-8322-9671-4

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	3
INTRODUCTION.....	5
1 Scope.....	6
2 Normative references .....	6
3 Terms, definitions and abbreviated terms .....	6
4 Atmospheric conditions for evaluation and conditioning .....	7
5 Measuring methods and instruments .....	7
5.1 Measuring instrument.....	7
5.2 Preparation of specimen .....	8
5.3 Measuring method .....	8
5.4 Obtaining void-related attributes .....	10
6 Report of results .....	10
6.1 Measurement identification information .....	10
6.2 Instrument system and its specification .....	11
6.3 Sampling position .....	11
6.4 Results .....	11
Annex A (normative) Void threshold.....	12
Annex B (normative) Additional attribute from measurement – Size distribution of voids.....	17
Bibliography.....	18
Figure 1 – Definition of pattern area and background area in the ROI of the captured image .....	8
Figure 2 – Distribution of the brightness of the pixels of the pattern area and mean value, and distribution of the brightness of the pixels of the background area and mean value.....	9
Figure 3 – Binarization of pattern and detected voids.....	10
Figure A.1 – Different images of a void .....	12
Figure A.2 – Dependence of the void threshold on the void threshold index .....	12
Figure A.3 – Distribution of the brightness of pixels of the printed pattern and effect of Z.....	13
Figure A.4 – Example of void detection depending on Z.....	14
Figure A.5 – Additional examples of void detection depending on Z .....	15
Figure A.6 – Total numbers and areas of voids in the sample images of Figure A.4 and Figure A.5.....	16
Figure B.1 – Size distribution of voids in the sample images of Figure A.3 or Figure A.4.....	17
Table 1 – Reporting items example .....	11

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## PRINTED ELECTRONICS –

**Part 402-3: Printability – Measurement of qualities –  
Voids in printed pattern using a two-dimensional optical image**

## 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.

International Standard IEC 62899-402-3 has been prepared by IEC technical committee 119: Printed Electronics.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
119/346/FDIS	119/350/RVD

Full information on the voting for the approval of this International Standard 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.

A list of all parts in the IEC 62899 series, published under the general title *Printed electronics*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The "colour inside" logo on the cover page of this document 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 document contains fundamental information on the measurement of voids in a printed pattern in printed electronics. Void in this document is defined as a very small non-patterned part of a printed pattern, caused by the printing condition and ink properties, and treated as two-dimensional on a substrate. It can be seen that the terms void and pinhole used in the electronics and graphic printing industries, and the term void used in this document are different. There can be three kinds of absence of materials in the pattern. First, an absence of material inside the solid pattern, which is generally called void in the electronics industry. In this case, there is a vacancy inside the pattern but no imperfection area observed from a two-dimensional (2D) top-view. Therefore, it cannot be defined in the graphic printing industry where only two-dimensional (2D) images are meaningful. Second, there can be a hole penetrating from the surface of the printing layer to the substrate. This case can be observed as a hole in the printing area, and is called a pinhole in the electronics industry and a void in the graphic printing industry, respectively. The third one is a deep hole that does not penetrate into the substrate, therefore it is observed as a hollow in a 2D top-view of a printing image. In the electronics industry, this case is called hollow or pit, and in the graphic printing industry, it is called hollow or void in general. This document deals with the second and third cases, and focuses on the 2D image of the printed pattern; therefore, the term void is used in this document according to the generally used definition in the graphic printing industry. Voids should not exist in the printed patterns which constitute the printed electronics devices to be commercialized for the stable and reliable performance of the devices. The detection and analysis of voids in the pattern can provide guidelines to evaluate the printability of the process, inks, and equipment, therefore, it is possible to manage and control the performance of the printed electronics devices by measuring and analysing the voids at the patterning process from the point of view of printability. An easy way to detect voids in the printed pattern can be to use a three-dimensional (3D) profiler, however, it is too expensive to install in small-sized manufacturing facilities. Therefore, this document provides a measurement method of voids using a 2D image obtained by a conventional optical microscope or camera. This document includes the measurement procedures of voids and related attributes such as numbers, size, and ratio of voids within the pattern. In the area of the void, the thickness of the pattern changes gradually: the pattern thickness decreases gradually and finally becomes zero at the void, which is a three-dimensional characteristic of the void. The boundary of the void can be different depending on the definition of the meaningful thickness of the pattern near the void area. This document offers a method to determine the boundary between the void and the pattern. Although this document offers a measurement method of voids from the two-dimensional image of the printed pattern, it gives a proper method that can capture the voids considering their three-dimensional structure even from the two-dimensional photo image of the pattern. This simple cost-effective measurement method can offer an easy way to check the voids in the printed pattern in the manufacturing process, and can be useful way for the printed electronics industry to manage the quality of the products at lower cost.

This document excludes the standardization of the measurement system. It specifies the properties related to the voids such as numbers, areas, sizes, etc., in the printed pattern obtained from the optical measurement system.

Operators should avoid misdetection of voids from deeply rough surfaces on the thick pattern such as printed by screen-printing. It is recommended that surface roughness be measured as well for these cases.

## PRINTED ELECTRONICS –

### Part 402-3: Printability – Measurement of qualities – Voids in printed pattern using a two-dimensional optical image

#### 1 Scope

This part of IEC 62899 specifies the optical measurement method for acquiring two-dimensional images of voids and obtaining the void-related attributes in the dried or cured printed patterns which are part of the electronic products in the field of printed electronics. The measurable voids using this document are limited to those that are distinguishable by the optical image measurement.

NOTE In this document, void means an imperfection of pattern observed from a two-dimensional (2D) top-view.

#### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 291, *Plastics – Standard atmospheres for conditioning and testing*

#### 3 Terms, definitions and abbreviated terms

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:

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

##### 3.1

##### **region of interest**

##### **ROI**

area, inside defined boundaries, to be analysed

##### 3.2

##### **background area**

part of the area in the ROI that contains the background, excluding the patterned part

##### 3.3

##### **pattern area**

part of the area in the ROI that contains the patterned part, and which may include voids, excluding the background

##### 3.4

##### **void**

absence of ink in an area that should be inked