IEC 62899-302-6

Edition 1.0 2025-05

INTERNATIONAL STANDARD

Printed electronics –
Part 302-6: Equipment – Inkjet – First drop measurement

ICS 19.080; 37.100.10

ISBN 978-2-8327-0414-1

IEC 62899-302-6:2025-05(en)

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2025 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 Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
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
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 It also gives information on projects, replaced and withdrawn publications.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
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
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

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

CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 7
2 Normative references 7
3 Terms, definitions and abbreviated terms 7
3.1 Terms and definitions 7
3.2 Abbreviated terms 8
4 Inkjet first drop measurement 8
4.1 General 8
4.2 Process for printing-based method 8
4.3 Process for high speed camera imaging-based method 9
4.4 Process for single flash imaging based method 10
5 Recorded operating parameters for drop speed measurements 11
Annex A (normative) Key considerations for inkjet first drop measurement 12
A.1 Printing measurement 12
A.2 High speed camera based measurement 15
A.2.1 General 15
A.2.2 Measurement steps using high speed camera 16
A.2.3 Analysis method of acquired images 18
A.2.4 Jetting speed measurement for first drop analysis 20
A.3 First drop measurement using imaging device (CCD camera) with flash light source 22
Bibliography 24

Figure A.1 – Typical first drop effect 12
Figure A.2 – Jetting speed effects on drop placement 13
Figure A.3 – Patterns for first drop evaluation 14
Figure A.4 – Practical guidelines to obtain acceptable printing accuracy 15
Figure A.5 – Vision measurement based on high speed camera 16
Figure A.6 – Trigger based image acquisition and jetting for first drop measurement. 17
Figure A.7 – Non-jetting pause time effects on the first drop jetting speed 18
Figure A.8 – Sorted drop images (ink type A) 19
Figure A.9 – Sorted drop images (ink type B) 19
Figure A.10 – Two jetting images of a droplet, to calculate jetting speed 20
Figure A.11 – Jetting speed calculation from the droplet locations at two timings 21
Figure A.12 – Jetting speed behaviour according to non-jetting time 21
Figure A.13 – Timing chart for CCD camera based measurement 23

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

PRINTED ELECTRONICS –

Part 302-6: Equipment – Inkjet – First drop measurement

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62899-302-6 has been prepared by IEC technical committee 119: Printed Electronics. It is an International Standard.

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

Draft	Report on voting
119/534/FDIS	119/543/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

Drop-on-demand inkjet printing has been used as a manufacturing tool for printed electronics. The use of inkjet has many advantages since an exact amount of droplets can be deposited on target locations without wasting excessive amount of materials. To position the inkjet head on the printing location, jetting from the inkjet head should be paused for a while. As a result, it has been well known that the initial first few drops, after the non-jetting pause time, can be different from that of the steady state jetting. The abnormal behaviours of the first few drops can cause serious printing quality problems. Also, it could produce poor yield when used in manufacturing process. So, the proper evaluation of first-drop failures has been important steps for inkjet process development.

Moreover, substrates can be unloaded and loaded for printing, especially in printed electronics applications. By using a fiducial camera to view the substrate, the printing target position in the substrate is identified via alignment marks on substrates. Also, the substrate should be aligned with respect to motion stage axes prior to printing. It can take considerable time and the jetting should not occur during the preparation for printing. Due to the non-jetting period, ink on the nozzle surface can dry, and consequently the jetting behaviours of the first few drops are likely to differ from those of steady-state jetting. If the abnormal jetting behaviour is significant, printing quality can be affected accordingly. As a result, a proper measurement method should be developed to evaluate the jetting failure.

The main cause of the first drop behaviour including low jetting speed and non-jetting status can be from the ink drying on nozzle substrates. However, apart from the ink solidification on substrate, it can be affected by jetting frequency. The piezo type inkjet head uses pressure waves generated inside of the head. The first drop is not affected by the residual pressure waves from the previous drops. However, from the second drops, the jetting can be affected by residual pressure waves from the previous jetting. Also, pressure wave amplification is different according to jet frequency due to residual pressure. Thus, the first drop behaviour might be affected. This document provides the measurement and analysis method for first drop dissimilarity but does not provide the method to decide the cause of the non-similarity of first drops. Nonetheless, by engineering judgement, the causes of first drop dissimilarity can easily be determined.

In order to measure inkjet behaviour, the methods using drop visualization systems based on a light emitting diode (LED) have been standardized. The methods are useful because real-time monitoring is possible by using a charge-coupled device (CCD) camera. However, the method has difficulty and limitations in measuring the transient jet behaviour of the first few drops because it uses a low-frame rate (~30 frame/s) CCD camera. Nevertheless, the conventional hardware for drop visualization system can be used for first drop measurement by modifying the measurement methods.

In this document, the measurement method and guidelines will be presented including the method using a CCD camera illuminated by pulsed light. Other methods are also presented including the methods based on high speed camera as well as printing system. Most printing systems are capable of inspecting printed dots right after printing. Printed patterns can be effectively used for evaluation of first few drops in relations to various parameters.

On the other hand, the price of high speed camera is becoming cheaper and the performance is improving. The hardware requirement and synchronization method is relative simple when the high speed camera is used for measurement. In addition, the method using high speed camera does not require an expensive printing system and first drop effects can be effectively analysed.

Each method has merits and limitations and this document does not recommend specific methods.

The evaluated first drop behaviour can be used for ink development to improve jetting quality. Also, it can be used for process development such as pre-spitting (or pre-jetting) method and head control method (for example, meniscus excitation method).

PRINTED ELECTRONICS –

Part 302-6: Equipment – Inkjet – First drop measurement

1 Scope

This part of IEC 62899 specifies the method for determining inkjet first drop behaviour based on either visualized droplet images or printed dots on standard substrate. The exact behaviour that is referenced in this document is as follows: jetting speed variation according to the drop numbers, including non-jetting and low jetting speed. This measurement standardization is limited to drop-on-demand type of inkjet including piezo and thermal types and is not applicable to continuous inkjet. This document includes the test equipment, printing procedures, and analysis of drop behaviour. This document is limited to printed electronics application and is not suitable for graphic or other applications.

2 Normative references

There are no normative references in this document.