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INTERNATIONAL STANDARD

colour inside

Printed electronics –
Part 302-3: Equipment – Inkjet – Imaging-based measurement of drop direction

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

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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PRINTED ELECTRONICS –

Part 302-3: Equipment – Inkjet – Imaging-based measurement of drop direction

FOREWORD

International Standard IEC 62899-302-3 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
119/332/FDIS	119/344/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 document 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 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

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- withdrawn,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

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

Establishing the jetted drop direction under specific operating conditions of inks and inkjet print-heads is significant for accurate drop placement during the manufacture of printed electronics. Manufacturers that include such print-heads in their equipment should know the angular spread of ink drop directions because this influences the achievable spatial resolution of the printed material, and in particular whether any neighbouring conducting tracks could be connected by stray materials, which would affect the printed electronics' product performance. This document defines the methods for in-flight imaging measurement of jetted drop direction from drop-on-demand type inkjet print-heads to be used in printed electronics equipment.

PRINTED ELECTRONICS –

Part 302-3: Equipment – Inkjet – Imaging-based measurement of drop direction

1 Scope

This part of IEC 62899 specifies in-flight imaging methods for the measurement of the direction of ink drops jetted from inkjet print-heads using drop watchers. It does not apply to holographic or other interference techniques, or to any method assessing deposited ink drops. It is specific to drop-on-demand type inkjet print-heads (used in printed electronics equipment).

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.

IEC 62899-302-1, *Printed electronics – Equipment – Inkjet – Imaging based measurement of jetting speed*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62899-302-1 and the following 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
inkjet nozzle plane
flat outer surface of the inkjet print-head nozzle plate

Note 1 to entry: The inkjet nozzle plane is defined for a drop-on-demand multi-nozzle print-head, or as otherwise specified by the print-head manufacturer or inkjet equipment integrator and stated in the measurement results.

3.2
nozzle row direction
line in the inkjet nozzle plane passing through a row of nozzle exit centres

Note 1 to entry: Typically along the length of the inkjet nozzle plane, or as otherwise specified by the print-head manufacturer or inkjet equipment integrator and stated in the measurement results.

3.3
reference direction
normal angle (90°) to the inkjet nozzle plate

Note 1 to entry: Or as otherwise specified by the print-head manufacturer or inkjet equipment integrator and stated in the measurement results.

3.4
measurement region
3-D space closest to the inkjet nozzle plane used for imaging of the jetted drops

3.5
drop trajectory
direction of drop travel in 3-D in the measurement region

Note 1 to entry: It can be measured with two drop watchers mounted with a wide angle between them simultaneously imaging jetted drops.

3.6
trajectory angles, pl.
two orthogonal angles necessary to define the drop trajectory

Note 1 to entry: The polar angle is relative to the reference direction; the azimuthal angle is relative to a specific direction within the nozzle plane, often assumed to be the nozzle row direction.

3.7
projected angle
angle of the drop trajectory in the 2-D image plane of a single drop watcher

Note 1 to entry: The projected angle does not correspond to the polar angle of the drop trajectory unless the azimuthal angle is 0° or 180°.

3.8
reference speed
speed of the drop along the reference direction

3.9
projected speed
speed of the drop along the projected angle

3.10
absolute speed
speed of the drop along the drop trajectory

4 Measurement methods

4.1 General

The jetted drop direction shall be determined by using one of the following methods, unless there is an agreement between the user and the supplier. In that case the method is fully reported with the measurement results.

All equipment engaged in the trajectory measurement shall have a carefully calibrated geometry.

The image plane shall be aligned in a precisely orthogonal direction to the inkjet nozzle plane before the start of the measurement.

4.2 Process for projected angle using one double flash drop watcher (method 1)

1) Establish reliable jetting from the nozzle under study in the image measurement region.
2) Record the images and analyse the drop image position changes for the chosen double flash delay.
3) Report the projected angle, using the formula provided in A.2.1.
4) Report the conditions as indicated in Clause A.3.

4.3 Process for projected angle using one single flash drop watcher (method 2)

1) Establish reliable jetting from the nozzle under study in the image measurement region.
2) Record a single flash image of a jetted drop and of the nozzle under study and analyse the drop and nozzle exit image positions. Alternatively, record two single flash images of two separate drops jetted at different times from the nozzle under study, and analyse the single flash drop image positions.
3) Report the projected angle, using the appropriate formula specified in A.2.2.
4) Report the conditions as indicated in Clause A.3.

4.4 Process for projected angle using one strobe flash drop watcher (method 3)

1) Establish reliable jetting from the nozzle under study in the image measurement region.
2) Record a strobe flash image, at a chosen flash delay time, of the nozzle under study and the superposed drops, and analyse the image positions of the nozzle exit centre and the superposed drops. Alternatively, record two strobe flash images, at two different delay times, of two separate drops from the same nozzle, and analyse the change of the single flash image positions.
3) Report the projected angle, using the appropriate formula specified in A.2.3.
4) Report the conditions as indicated in Clause A.3.

4.5 Process for trajectory angles using two double flash drop watchers (method 4)

1) Establish reliable jetting from the nozzle under study in the image measurement region, with the image planes of the two double flash drop watchers having a wide angle between them aligned with a common axis along the reference direction.
2) Record double flash images of the same drop in each drop watcher for the chosen double flash delay times and analyse the drop image positions in each double flash drop watcher.
3) Report the trajectory angles, using the appropriate formula specified in A.2.4.
4) Report the conditions as indicated in Clause A.3.

4.6 Process for trajectory angles using two single flash drop watchers (method 5)

1) Establish reliable jetting from the nozzle under study in the image measurement region, with the image planes of the two single flash drop watchers having a wide angle between them aligned with a common axis along the reference direction.
2) Record single flash images of the same drop and nozzle exit at a chosen delay time in each drop watcher and analyse the image positions of the drop and nozzle exit centre in each single flash drop watcher. Alternatively, record images, at chosen delay times in each single flash drop watcher, of separate drops jetted from the nozzle under study, and analyse the single flash drop image positions in each drop watcher.
3) Report the trajectory angles, using the appropriate formula specified in A.2.5.
4) Report the conditions as indicated in Clause A.3.

4.7 Process for trajectory angles using two strobe flash drop watchers (method 6)

1) Establish reliable jetting from the nozzle under study in the image measurement region, with the image planes of the two strobe flash drop watchers having a wide angle between them aligned with a common axis along the reference direction.
2) Record strobe flash images of the superposed drops and nozzle under study at a chosen strobe flash delay time and analyse the image positions of the nozzle exit centre and superposed drops in each strobe flash drop watcher. Alternatively, record strobe flash images, at two different delay times, of separate drops jetted from the nozzle under study, and analyse the superposed drop image positions in each strobe flash drop watcher.
3) Report the trajectory angles, using the appropriate formula specified in A.2.6.
4) Report the conditions as indicated in Clause A.3.

Annexe A
(informative)

Determination of jetted drop direction

A.1 Imaging-based measurements of jetted drop direction

The jetted drop direction should be determined from drop image position measurements for at least two different points in three-dimensional space. While IEC 62899-302-1 determines 2-D components of drop velocity it does not explicitly consider imaging-based measurement of the spatial components necessary to specify the jetted drop direction (or velocity) in 3-D space.

This document also uses just two different points to define the jetted drop direction, by assuming a straight-line motion and the absence of electrical and gravitational effects on jetted drops. All the drop watcher types are assumed to provide a flat 2-D image plane in this document, with the camera image plane aligned orthogonally to the inkjet nozzle plane. This alignment can be checked using reliably jetted drops with different delays spanning the region of interest in the camera image plane. Drop trajectories for drop-on-demand printed ink drops studied using multiple flashes, high-speed photography and orthogonally mounted drop watchers showed straight line motion holds in the absence of sideways aerodynamic and significant electric field effects. The effects of gravity as compared with air drag forces acting on near-vertically jetted drop-on-demand inkjet drops are usually negligible.

In-flight imaging measurement methods are not based on the final printed drop position or any other print quality (PQ) assessment methods applied to inkjet-printed electronics products. By contrast, the measurement of printed drop positions on a fixed substrate defines final 3-D locations at the expense of accurate knowledge of in-flight drop directions, and importantly does not accurately determine the drop trajectory close to the nozzles, i.e. where jetted drops are fully formed and furthest from their final printed positions.

Drop watchers provide the direct means of observing the region of interest for free-flying jetted drops, although practical considerations can prevent the imaging of the nozzle exit. The extent of the region of interest will depend upon these practical limits and the flash delay times chosen, together with drop speed and the drop formation process, which in turn depend on the ink properties and the particular inkjet print-head technology. Drop travel (throw) distances from the jetting nozzle to the printed substrates are typically less than 1 mm; completion of the drop formation process to give near-spherical droplets can require 100 µm travel from the nozzle. The region of interest for the measurement of jetted drop direction would be around 100 µm to 300 µm from the nozzle, but not near a substrate.

In-flight determination of the jetted drop direction relies on double flash drop watchers or single flash drop watchers or strobe flash drop watchers taking one or more images of a single drop or of different drops (and possibly the nozzle exit). Only methods such as that using two double flash drop watchers can provide a direct measurement of the drop trajectory for a single drop. Single flash drop watchers provide a projected angle based on image positions for different drops (or possibly one and the nozzle exit), at two different single flash delays. Strobe flash drop watchers provide an inherently representative average measured image position for a number of superposed drops and a projected angle based on inherently representative average measured image positions for two sets of superposed drops (or possibly one set and the nozzle exit) at different strobe flash delays. This hierarchy of methods should be associated with increasing uncertainties in the quoted projected angle and in the quoted trajectory angles. The method used should always be reported, whether based on this document or under an alternative user-supplier agreement.