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TECHNICAL REPORT

Printed electronics – Part 302-5: Equipment – Inkjet – Significant characteristics of inkjet printing

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IEC Secretariat
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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FOREWORD

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

Draft	Report on voting
119/421/DTR	119/439/RVDTR

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 Technical Report 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

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- withdrawn,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

INTRODUCTION

Until recently, inkjet technologies were used only for imaging printing (conventional ‘graphic printing’). However, the recent development of inkjet technologies, such as technologies for inkjet print-head, functional ink, or print-head driving technologies, now makes it possible to apply these technologies for another area called functional printing, such as printed electronics.

Unlike conventional imaging printing, functional printing requires to have a very precise ink drop position so as to bring a functionality to what is produced. If the ink drop position is not exact, the expected function cannot be realized because the electronic connection secured by the ink drop position is vital for the electronic function of the final product. For example, when producing 2 000 imaging pixels by 1 000 imaging-pixels display, that display would have at least 2 000 × 1 000 = 2 000 000 active-matrix circuitries in order to show an image by that display. In addition, and because of the complexity of the above-mentioned circuitries, functional printing requires a higher resolution. Usually, an active-matrix circuitry consists of several active and passive electrical components, such as transistors and capacitors. Each component is usually made (or printed) using certain layers of different printed materials. Any printing defect in an active-matrix circuitry will be catastrophic for the performance of the printed device, such as shorted circuitry; when that display shows a uniform image, such as whole white or whole black image, that image shown by a display with a defect would be pretty obvious for a viewer because human eyes are very keen for a small number of detects in a uniform image. From that sense, a defect in a complex circuitry would be a big issue for an entire printed electronics device.

On the other hand, for imaging printing, a dropped ink position would not affect the image quality of that image as much as for functional printing, because usually a defect (for example, one dot does not have a dropped ink at all in the whole black image) will not be so obvious for human eyes.

Another important difference between functional printing and imaging printing by inkjet printing technologies is due to the fragmentation in the supply chain of the functional printing electronics markets. For imaging printing, until recently a vendor would provide inks, printing equipment including inkjet heads, and sometimes a printing substrate, paper. That means that the vendor could directly control the quality of all these elements. However, for functional printing, the functions come from inks, and inks usually come from ink vendors that are specialized for inks, and inkjet heads come from an inkjet head vendor that is specialized in inkjet heads. Sometimes, a printing equipment vendor makes their own printing equipment by using several inkjet heads. Obviously, a substrate is not always paper, but can consist of several kinds of film, such as plastic films, or metal foils, or both. That means vendors cannot control the whole process of printing but have to work closely with other vendors. Thus, for inkjet printing especially for printed electronics, it is extremely useful to have certain ways of evaluating functions of each component that compose functional printing.

This document explores what kind of characteristics of inkjet printing will be considered to obtain functionable printed electronics device(s), for example detailed characteristics of inkjet head(s).

PRINTED ELECTRONICS –

Part 302-5: Equipment – Inkjet – Significant characteristics of inkjet printing

1 Scope

This part of IEC 62899 provides the significant characteristics, parameters and system properties that are relevant for functional inkjet printing for printed electronics. Where possible, existing measurement standards and specifications are cited.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Inkjet printing

4.1 General

Generally, the purpose of printing is to put some material onto other materials. In that sense, ”printing” is sometimes called ”deposition”.

For imaging purposes, ”printing” means putting pigments or dye, which can contain colour, onto a substrate. A pigment and dye can reflect or sometimes emit light to form an image.

For electrically functional printing, ”printing” means putting electrically functional material onto a substrate. A functional material can show function(s), somehow. For printed electronics, ”printing” means putting electrically functional material(s) onto a substrate; for example,

1) an organic material that emits light when a correct electric current is applied,
2) a passive layer that protects the material under that layer, and
3) an insulating layer that electrically insulates between other materials or layers, or both.

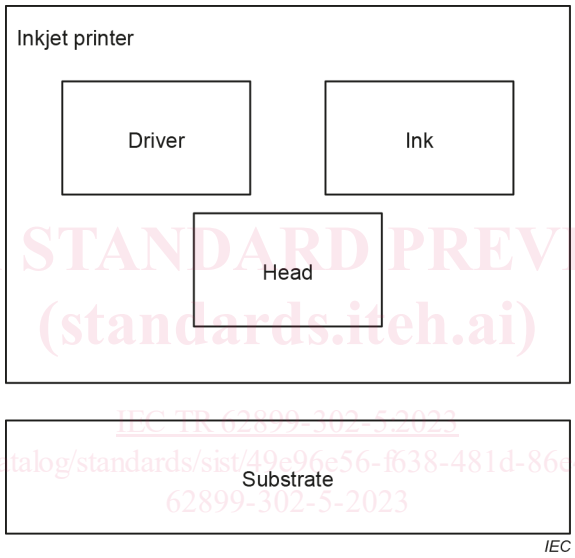
Material put onto a substrate can realize function(s). In order to have (a) proper function(s) by a printed material, the printed position of the material is very important

4.2 Issues of functional printing

As stated in the introduction, functional printing will have highly accurate printed positions for printed electronics applications. For example, a thin-film-transistor (TFT) made by printed electronics consists of several active components and passive components. Each component consists of several layers of printed or non-printed materials. In order to have a proper functional device, it is important that each component will have a proper function. In order to have a proper functional component, each material will show the proper function. In order to have a proper functional material, a proper material will be placed at the proper position. In order to have the proper material at the proper position, each material will be accurately placed. Thus, the accuracy of the placement of the printed material is one of the important key parameters for functional printing especially in printed electronics.

4.3 Components of inkjet printer

Figure 1 shows the typical example of an inkjet printer configuration.



NOTE Figure 1 shows only the major components. There are other components in an inkjet printer.

Figure 1 – Example of inkjet printer configuration

In 4.4 to 4.7 the physical parameters related to printed quality, especially dot placement, are described.

4.4 Characteristics of inkjet head

4.4.1 General

There are two major ink dropping (jetting) types, the one is called a continuous dropping (jetting) type that an inkjet head drops ink continuously, not stopping, and the other is called an intermittent dropping (jetting) type that an inkjet head does not drop ink continuously, but intermittently.

The inkjet head has several properties related to printed quality. The major ones are static physical properties and others are dynamic physical properties.

4.4.2 Static physical properties

4.4.2.1 General

Typical static physical properties that affect printing quality are shown in Table 1.

Table 1 – Static physical properties of inkjet head

Property	Subclause
Nozzle position	4.4.2.2
Nozzle layout	4.4.2.3
Shape of nozzle	4.4.2.4
Size and number of nozzles	4.4.2.5
Mounting position	4.4.2.6
Distance between print head(s) and substrate	4.4.2.7

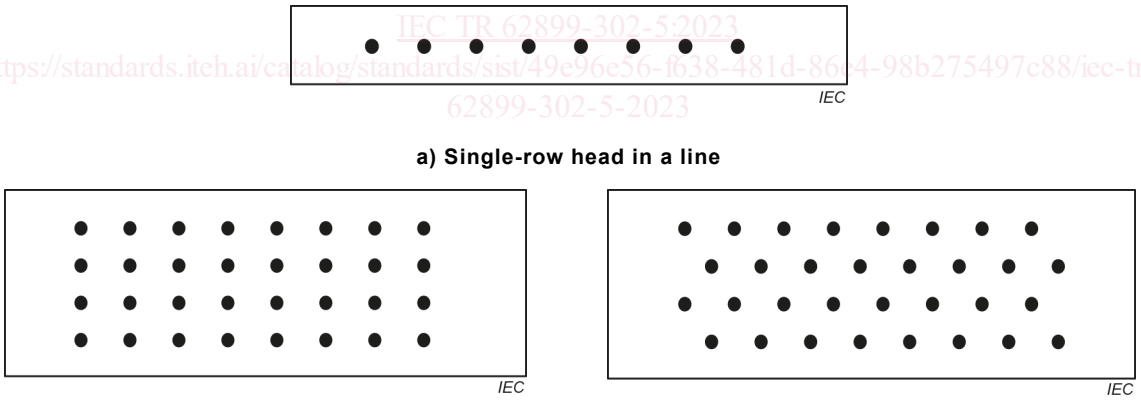
4.4.2.2 Nozzle position

The accuracy of the nozzle position directly affects the dot placement. In order to obtain an accurate print, accurate nozzle positions are maintained.

The measurement method of the nozzle position is the generic measurement method of the relative position from a reference point.

4.4.2.3 Nozzle layout

Typically, an inkjet head has multiple nozzles arranged in a line, or other shapes. In most cases, the nozzles are arranged in a line at a fixed interval. In order to achieve a resolution higher than the pitch of nozzles that can be arranged in a row, there is a multi-row inkjet head design in which multiple nozzle rows are arranged in a row in a single head (see Figure 2). Apparently, this property can affect the accuracy of the printed result.



a) Single-row head in a line

b) Multi-row head in lattice arrangement

c) Multi-row head in staggered arrangement

Figure 2 – Examples of nozzle layout

4.4.2.4 Shape of nozzle

The accuracy and type of shape of the nozzle (of the inkjet head) directly affect the dot placement. In order to obtain accurate inkjet print, the accurate shape of the nozzle is adequately maintained.

4.4.2.5 Size and number of nozzles

The accuracy of the size of the nozzle (of the inkjet head) directly affects the placement of dots. the number of nozzles will also affect the placement. In order to obtain accurate inkjet print, the accurate size of the nozzle is adequately maintained, and the proper number of nozzles is obtained to have proper printing speed and accuracy.

4.4.2.6 Mounting position

The accuracy of the mounting position (of the inkjet head) directly affects the dot placement. In order to obtain accurate inkjet print, the accurate mounting position is adequately maintained.

The measurement method of the mounting position is the generic measurement method of the relative position from a reference point.

4.4.2.7 Distance between print head(s) and substrate

The accuracy of the distance between the print head(s) and the substrate directly affects the dot placement. In order to obtain accurate inkjet print, an adequate distance between the print head(s) and the substrate is maintained. The proper distance between the print head(s) and the substrate is dependent upon many parameters of the inkjet head(s), for example ink, temperature, humidity. In order to keep the proper distance, those parameters are studied, and the distance is maintained throughout the printing duration.

4.4.3 Dynamic physical properties

4.4.3.1 General

The typical dynamic physical properties that can affect the printed result are shown in Table 2.

Table 2 – Dynamic physical properties of inkjet head

Parameter	Subclause
Print sequence	4.4.3.2
Head movement	4.4.3.3

4.4.3.2 Print sequence

Depending upon the inkjet printer apparatus, the print sequence is set as you wish as far as the inkjet printer apparatus can print. Print sequence means the order in which an inkjet printer dispenses ink onto the substrate.

4.4.3.3 Head movement

The accuracy of movement of the printing substrate relative to the inkjet head directly affects dot placement. This can be achieved in two ways. The first is to keep the head stationary and move the substrate, the second to move the print head, often on a reciprocating pattern.

In order to obtain accurate inkjet print in this second case it is necessary to maintain accurate movement of inkjet head. In order to facilitate this, there are several parameters to consider, such as the moving profile and the moving mechanism, among others.

The measuring methods of movement are generic measuring methods of movement, such as gyro sensor.

4.5 Controlling inkjet head

4.5.1 General

4.5.1.1 Overview

The parameters of the controlling inkjet head (driving inkjet head) that affect the dot placement are shown in Table 3.