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Graphic technology — Determination of the energy consumption of digital printing devices including transitional and related modes

Technologie graphique — Détermination de la consommation d'énergie des dispositifs d'impression numérique en modes transitoires et connexes

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 130, *Graphic technology*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The energy requirement of digital production printing devices varies considerably across technologies, output formats, and productivity and quality expectations. Run length influences the overall energy usage, so the energy consumption of devices used for relatively short run lengths is accompanied by the relatively high amounts of transitional energy, including surge power, required to complete the print run. Operating transitions contribute to the overall energy profile throughout the course of operations, with frequent interventions between production printing modes.

As a proportion of the overall energy requirement for short run length jobs, transitional energy, including the surge energy, and waiting energy, including preparatory maintenance, will be substantial. This means that in order for the graphics industry to have accurate energy consumption data, directions are required to assist stakeholders in making accurate calculations for digital production printing devices, whose modes, other than production printing mode, play a significant role in the comprehensive energy consumption. This includes digital printing machines used to produce sign and display work, commemorative prints, photo books and similar high-value, on-demand print in narrow and wide formats.

This document provides directions for measuring any format of digital production press, whose modes, other than production printing mode, play a significant role in the comprehensive energy consumption.

This document can be used to compare the energy efficiency figures for different machine set ups: best-quality (slowest), highest-productivity (fastest) or other alternative combinations.

Application of this document provides the energy efficiency figures that correspond to the energy consumption for a digital printing device. These values can be used to inform the individual production scenarios covering different shifts, printing materials and other factors typical of the graphic arts.

Energy usage is generally estimated according to the connected load of a machine. The connected load is the machine's potential maximum power consumption. But calculated values do not necessarily reflect the machine's energy consumption. Actual energy consumption often differs significantly from estimated values. Power consumption data across devices can therefore not be accurately compared, since the calculations are unlikely to have followed a common framework that takes into account the influence of peripheral equipment such as IR or UV dryers. Nor can they accommodate differences in measurement cycles.

The universal availability of verifiable energy consumption data will enable print machinery buyers, printers and their customers to assess the power consumption of machines. However, the user of this document should understand that the effectiveness of power does not determine acceptable quality levels for the output that customers may require or expect. Power consumption is an important part of all the output requirements and quality expectation. This data can be used in life cycle analyses (LCA) and to calculate the carbon footprint of a printing system and of printed matter. Energy efficiency can be reported in various ways, such as the number of prints printed per kWh. This information can be used to:

— provide data for the LCA of a printing device;

— assess the power consumption and energy efficiency of digital printing production machines and peripheral devices;

— estimate operating costs for investment planning;

— benchmark the energy efficiency of digital production presses;

— calculate the CO_2 footprint of printed matter;

— encourage the energy efficiency improvements of digital printing devices over time;

— provide data to enable companies to claim environmental subsidies;

— provide data for carbon offsetting purposes.

This document defines how to calculate the electrical energy requirements and therefore the energy efficiency of digital printing devices.

This document can be used to determine the energy efficiency of any format of digital production press, whose modes, other than production printing mode, play a significant role in the comprehensive energy consumption.

Care should be taken when comparing the results obtained from this document that the devices being compared were set up to produce the same print quality using comparable types of printing technology, process and device configurations.

Graphic technology — Determination of the energy consumption of digital printing devices including transitional and related modes

1 Scope

This document provides directions for measuring and calculating the electricity consumption of any format of digital production press, whose modes, other than production printing mode, play a significant role in the comprehensive energy consumption. It excludes digital presses designed to print substrates other than paper or plastic and conventional printing presses fitted with digital inkjet printing heads.

It can be used to compare the energy efficiency figures for different machine combinations: best-quality (slowest), highest-productivity (fastest) or other alternative combinations.

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 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

3 Terms and definitions

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
digital printing machine
digital printing device
digital press
machine used in commercial/industrial applications where the printing image is produced in the machine from data stored in digital form and transferred to the substrate without the use of a printing plate

[SOURCE: ISO 12643-2:2010, 3.9, modified — “digital printing device” and “digital press” have been added to the term.]

3.2
electrical energy
E
electricity converted to other forms of energy (power, light, heat) for the operation of machines and devices

Note 1 to entry: Electricity generated in this way is calculated using the following formula:

$$E = \int_{t1}^{t2} u(t) \times i(t)\, dt$$

where $u(t)$ and $i(t)$ are the instantaneous values of voltage and current.

3.3
energy usage
power required for the operation of a given process over time

Note 1 to entry: Energy usage or electric energy consumption is typically measured in watt-seconds (Ws), kilowatt-hours (kWh) or watt-hours (Wh).

3.4
connected load
theoretically possible maximum power consumption of a machine, which can be expected when components of the printing machine are running at maximum load

Note 1 to entry: The connected load is the power specified by the manufacturer and used to rate the electrical power supply of the printing house (power rating, fuse rating, cable cross section). This ensures fail-safe operation of the machine under any possible operating condition. Determination of the connected load value has not been uniformly regulated so machine manufacturers handle it differently.

Note 2 to entry: The connected load should not be used to calculate a device's actual power consumption. This is always lower and in most applications, it is significantly lower.

[SOURCE: ISO 20690:2018, 3.3]

3.5
operational power consumption
power consumption of a machine in a defined operating condition or operational mode

Note 1 to entry: Typical operating modes are sleep, print-ready and production (also known as active mode).

3.6
active power
P
power available for conversion into other types of power

Note 1 to entry: mechanical, thermal or chemical power. In general, the active power of a consumer in a periodic AC voltage system can be determined with the formula

$$P = 1/T \int_0^T u(t) \times i(t)\, dt$$

where T is the desired period.

Note 2 to entry: Standard units are watts (W) and kilowatts (kW).

3.7
power meter
power analyser, which records voltages and currents as continuous values to determine power parameters

Note 1 to entry: These are high-precision devices designed for industrial use.

3.8
sleep mode
period when a printing machine is switched on, not running and operating with lower power than print-ready mode

Note 1 to entry: A reduced power state that a printing device automatically enters after a set period of inactivity (a.k.a. default delay time). Sleep mode permits operation of all product features (including maintenance of network connectivity), albeit with a possible delay to transition into print-ready or production mode.

3.9
print-ready mode
period when a printing machine is switched on with all assembled components (pre- and post-processing units) prepared to deliver outputs in the shortest time after a print order is given, compared with other waiting modes, such as sleep mode or off mode

3.10
production print mode
steady production print mode
period when a printing machine is printing live jobs

Note 1 to entry: A production print mode is characterized by a stable power consumption, when the printing machine is printing in a representative and typical fashion.

3.11
RIP
raster image processor which converts data into a raster bit stream or bitmap

3.12
machine combination
software, hardware and print media which has a direct influence on the resulting print image quality

EXAMPLE Best-quality combination = device configuration (hardware) + substrate (media) + print mode (software).

Note 1 to entry: RIP and print mode settings are examples of machine combination.

Note 2 to entry: When the settings depend heavily on the RIP and printing technology, the machine combination can also be referred to as the digital printing combination.

3.13
device configuration

physical hardware equipment included in a given production line

[SOURCE: ISO 20690:2018, 3.14]

3.14
basic device configuration
standard hardware equipment configuration as defined by the manufacturer, owner or user of the device for the type of printed products or market for which the press is being used

3.15
alternative device configuration
physical hardware configuration differing from the basic device configuration

[SOURCE: ISO 20690:2018,3.16]

3.16
print mode
collection of settings, that are used to control a given device configuration via software (RIP) to enable, disable or otherwise influence the operation of that device

EXAMPLE Using four colours on a machine capable of seven colours, varying the resolution, changing the speed or enabling duplex printing.

3.17
alternative print mode
collection of settings different from the print modes used for obtaining the best-quality or best-productivity combinations and used for defining additional combinations

3.18
imposition
fitting of test images (with no change to size) into the screen, sheet or unit length without overlapping

[SOURCE: ISO 20690:2018, 3.19]

3.19
imposition rate
ratio between the area of the imposed test images and the total area of the screen, sheet or unit length paper

Note 1 to entry: In this document, the imposition rate is used to calculate the equivalent A4 or Letter pages printed on larger paper formats, regardless of the original image size.

[SOURCE: ISO 20690:2018, 3.20]

3.20
nominal energy efficiency
E_{nom}
number of printed equivalent A4 pages or m^2 per kWh, measured in cruising state of production print mode, excluding the first page

Note 1 to entry: The number of output pages and the corresponding integral power are measured over the specified time.

3.21
effective energy efficiency
E_{eff}
number of printed equivalent A4 pages or m^2 per kWh, whose energy covers not only production print mode but also other relevant modes, such as print-ready, sleep, transitional and maintenance modes

3.22
transitional mode
start-up mode
period connecting two stable modes with different average power consumptions, i.e. “off mode and print-ready mode”, “sleep mode and print-ready mode” and “print-ready mode and production print mode”

3.23
maintenance mode
period required to maintain quality of devices, conducted regularly, for example prior to starting production print

3.24
first page print time
FPPT
number of seconds or minutes between the initiation of the job and the completion of the first cut sheet print or the completion of the first unit-page print imposed across the width of roll paper

Note 1 to entry: FPPT is measured from a stable condition of the relevant mode. For example, print-ready mode after the completion of a previous job may need a considerable time to stabilize because the heating unit needs several minutes for cooling to a stable, ready condition. If FPPT were measured before cooling off, the measured value could be shorter than that measured from a stable print-ready state, creating inconsistencies.

Note 2 to entry: In small format devices, FPPT is known as “first print out time” (FPOT). See ISO/IEC 17629:2014.

3.25
warm-up time
time required by the printing device to warm up from off mode, given by the difference in FPPT between off mode and print-ready mode

3.26
recovery time
time required by the printing device to recover from sleep mode given by the difference in FPPT between sleep mode and print-ready mode

3.27
copy
test form printed on a substrate regardless of being printed simplex or duplex

EXAMPLE 100 copies = 100 test forms printed on 100 sheets (simplex) or 50 sheets (duplex) or 100 images of the test form imposed on the given substrate.

3.28
consistency check
method for determining the stability and validity of two sequential measurements before averaging the results

EXAMPLE "5 % consistency" is satisfied when the first result value A and the second result value B meet $0{,}95 \leq 2A / (A + B) \leq 1{,}05$, where result value means reporting value (e.g. XX pages/kWh for "energy efficiency").

3.29
image quality adjustment
modifications made during printing to ensure print image quality that forces the printing system to pause production for a short period of time

Note 1 to entry: Image quality adjustments depend on many parameters such as test form area coverage or required quality level.

Note 2 to entry: Some printing devices will make image quality adjustments during printing to ensure print quality, where the devices continue moving without delivering any printouts.

3.30
unit under test
UUT
the digital printing device which is being measured

3.31
dummy print
preliminary job conducted in order to bring the UUT to print-ready mode

3.32
trailing edge
ridge line of printed cut sheet or imposed image form on roll paper, situated at the end along the transportation direction

3.33
job structure
typical work flow of the printing press per period (e.g. day) with power consumption levels along sequential modes

3.34
tonal coverage
cumulative colourant percentage

EXAMPLE A full sheet of 100 % deep black in CMYK has a tonal coverage = "400". The colourant coverage is defined by the tone value <data> as specified in ISO 12647-1.

Note 1 to entry: Typical coverage based on one colour plane are: light — 1 % to 9 %, medium — 10 % to 35 %, heavy — 36 % above.

[SOURCE: XJDF-Specification-2.0 Draft 2017-05-11[11]]

4 General conditions

4.1 Condition, age and machine configuration

How much power a digital printing device and peripheral devices uses is subject to many influences such as the selected print mode, equipment characteristics and their condition, ambient conditions, selected print speed, additional machine settings and the printing substrates used, especially their drying requirements.

The operational climate should comply with the following conditions and the actual conditions shall be documented:

— temperature: 20 °C–25 °C, and

— relative air humidity: 45 %–60 %.

Measurement of the operational climate parameters shall be made immediately before the start of the power measurement at a distance of 1 m from the front side of the paper input, at a height of 1,60 m above floor level.

The manufacturer, owner or user of a printing system shall determine a basic or standard device configuration that can be used for testing the two required machine combinations, best-quality and best-productivity. These two combinations shall be used for printing and measuring, to reflect the influence of the digital press's configuration on its power consumption and energy efficiency data.

— **Best-quality (BQ) combination**: The manufacturer, owner or user of a printing system shall select a device configuration, print mode and substrate for achieving the best possible saleable print quality. All colourants of the system shall be used.

— **Best-productivity (BP) combination**: The manufacturer, owner or user of a printing system shall use the same device configuration as used in the best-quality combination with a print mode and substrate for achieving the highest possible saleable productivity.

— **Alternative (AL) combination**: Using the same device configuration, alternative print modes are allowed (e.g. monochrome printing of a colour test page on a colour device, printing with four colours on a device capable of seven colours or changing the print resolution) and shall be reported as an alternative combination so as not to be confused with the mandatory best-quality or best-productivity combinations.

On a monochrome printing device, monochrome printing is not considered to be an AL combination and is to be tested in both BQ and BP combinations, if possible.

Electrophotographic processes have significantly fewer parameters affecting energy efficiency than inkjet printing. However, printing systems are available that allow for a change in print image quality, for example by adding a further colourant. If the printing press to be evaluated does not allow for a meaningful separation between BQ and BP, one machine configuration may be used. This machine combination shall be labelled best-quality/best-productivity (BQ/BP).

AL device configurations may include additional pre- or post-handling or print and output enhancement equipment (e.g. sheeting, folding, binding, seven colours, substrate enhancement or manipulation) under the condition that the additional equipment is built in as part of the production line (in-line). Any AL device configurations shall be seen and reported as a different device configuration and tested in both BQ and BP combinations as defined by the user of this document.

A PDF file of the output image shall be attached to the test report to show the test has been conducted with suitable image quality.

To demonstrate that prints are of adequate quality, colour accuracy should fulfil the requirements of ISO 12647-8:2012, 5.2. This ensures that the required ink coverage is used for test prints. However, this test does not fully measure the colour accuracy of the printing system.

4.2 Connection conditions

Digital printing systems, including pre-and post-processing units shall use one- or three-phase connection, 50 Hz–60 Hz and 100 V–650 V. The power supply quality and the voltage tolerance shall comply with IEC 60204-1 or equivalent.

Measurements may be performed on more than one outlet. Typical connection points are:

— main printing unit (main switch cabinet);

— paper feeder;

— paper delivery unit;

— external cooling units that can be directly attributed to the printing system;

— digital front end (RIP); and

— viewing cabinet.

All units that are required for printing but that can't be attributed directly to the printing press (e.g. a centralized pressure, air conditioning or cooling system) shall be estimated using averaged power consumption values provided by the manufacturer. The method used shall be reported.

For units which can be directly attributed but for which power consumption varies with outside temperatures, the actual temperature shall be reported. The average annual energy consumption based on an average temperature of 10 °C and 20 °C should also be reported.

EXAMPLE A chiller or air conditioning unit mounted on the roof of a printing site might be connected directly or indirectly to a press, but its power consumption relies on the outside temperature. Although for an outside temperature of about 30 °C the device is constantly in operation, it might run only a fraction of the time when the outside temperature is 10 °C or less. In order to account for this effect, the power consumption can be estimated for two temperatures that represent different (cooler or warmer) climates. To accomplish this, one would conduct power measurements or deduce the power based on the manufacturer data sheet provided for temperatures around 10 °C and 20 °C. When performing power measurements, the recommended measurement time is at least 1 hour.

4.3 Printing conditions and operational modes

4.3.1 General

The printing conditions, including the substrate used, shall be based on the machines' BQ and BP combinations and may also cover AL machine combinations. All combinations should be documented in conformance with Annex A (measurement data sheet).

For printing, an unscaled one-page PDF test form shall be used. Any image can be used for the power consumption measurement, as long as its contents represent practical commercial images with an area coverage up to 40 % per channel, calculated by using tone value data as defined in ISO 12647-1. It is advisable to use recognized test forms, such as that in ISO/IEC 24734:2014, B.2. The PDF file for the test form shall be in A4, Letter or A3 format. The test form used shall be documented by means of a PDF file of the printed image alongside the measurement data sheet.

Two-sided printing (duplex) may also be used. When two-sided printing is used, the same image shall be printed on both sides of the sheet and the printed pages shall be included in the calculation of the printed area or number of pages.

Large format presses, including those designed to accommodate continuous-form media greater than or equal to 406 mm wide, are designed for A2 media and larger[9]. Duplex printing may be used by means of the optional print modes or accessories and the associated reporting shall cover this in an unambiguous manner. For large format presses the pages shall be imposed to fill at least 66 % of the total available substrate width. The imposition rate will be taken into consideration, see 4.6.

