TECHNICAL SPECIFICATION

ISO/TS 19857

First edition
2021-06

Paper, board and printing inks – Printability – Laboratory test method for offset ink setting

Papier, carton et encres d'impression – Imprimabilité – Méthode d'essai de laboratoire pour le séchage de l'encre offset

Reference number
ISO/TS 19857:2021(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

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

This document describes a test method to evaluate the ink setting characteristics of a specific ink/substrate combination in offset lithographic printing.

Set-off is the transfer of ink from the front of one sheet to the back or the front of the next sheet.

Setting is the process of penetration of liquid ink components of low viscosity into the penetrable substrate. These low-viscosity liquids within the ink are mineral oils, vegetable oils or esters of vegetable oils. By separation from those low-viscous liquids, the remaining ink film solidifies. This is combined with a varying change in the surface tack depending on the inks-varnish system and the time. The surface tack usually increases at the begin of the setting and later-on drops to zero. Setting is either the main drying mechanism for ink systems (e.g. news inks) or part of a multi-channel drying mechanism (e.g. conventional sheet fed offset inks or heatset inks). The laboratory test for setting performs a set-off print of the fresh print to a non-printed substrate at defined times. The ink transfer to the non-printed substrate not only depends on the degree of solidification of the ink by setting, but also on the actual level of tack of the original ink film. Thus, the test result is a combined measure.

The absorption properties of the paper are of great influence in offset lithography printing. Inappropriate absorption can lead to numerous printing problems such as ink set-off, bad adhesion, mottling, unpredictable tone value increase, poor rub resistance, damaging of first printed side on perfecting presses after perfecting and others.

The more absorbent the paper is, the less time will be needed for the ink to set sufficiently for further processing, but other properties can be affected adversely by fast ink setting. Very short times should be used when testing the processing of wet sheets, e.g. in a perfector press. Longer times are used for paper handling right after printing, and very long times are used for further processing such as folding and cutting.

Depending on the purpose of the test, there are three options for the paper-ink combination:

— Reference ink on production paper;

— Production ink on reference paper;

— Production ink on production paper, which can be divided into the following, depending on the application of the print:

  — Set-off face-to-face (e.g. set-off after folding);

  — Set-off face to back (e.g. set-off in a stack of paper).

Paper, board and printing inks – Printability – Laboratory test method for offset ink setting

1 Scope

This document describes a laboratory test method, using an IGT[1)]-type or a prüfbau[2)]-type printability tester, for the preparation of specimens to evaluate the absorption rate of an ink on a substrate in offset lithography by setting-off the printed surface to an unprinted surface.

This method describes testing with an amount of ink simulating either single colour or multi-colour printing. The print and the set-off print (counter print) are made with interval times, between print and set-off, common for the target process.

This method evaluates a particular ink and substrate combination.

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 5-4, *Photography and graphic technology — Density measurements — Part 4: Geometric conditions for reflection density*

ISO 2834-1, *Graphic technology — Laboratory preparation of test prints — Part 1: Paste inks*

ISO 2846-1, *Graphic technology — Colour and transparency of printing ink sets for four-colour printing — Part 1: Sheet-fed and heat-set web offset lithographic printing*

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
ink setting
process by which the ink dries by absorption and/or oxidation

3.2
set-off
effect produced when the ink on a print is transferred from the printed surface to another surface

1) These materials are available from IGT Testing Systems, www.igt.nl. This information is given for the convenience of the users of this document and does not constitute an endorsement by ISO of the products. Equivalent products may be used if they can be shown to lead to the same results.

2) These materials are available from prüfbau, Dr.-Ing. H. Dürner GmbH, www.pruefbau.de. This information is given for the convenience of the users of this document and does not constitute an endorsement by ISO of the products. Equivalent products may be used if they can be shown to lead to the same results.

3.3
set-off paper
counter-paper
paper used to make a counter print for *set-off* (3.2) evaluation

3.4
ink film
<on substrate> amount of ink applied on the surface of the substrate to obtain the required optical density of the print for the purpose of this test

Note 1 to entry: The amount is specified in g/m^2 or in µm.

3.5
ink film
<on printing forme> amount of ink applied on the surface of the printing forme for transfer to the substrate in the printing operation

Note 1 to entry: The amount is specified in g/m^2 or in µm. The ink film applied on the inking system is normally about double the amount from the amount transferred to the substrate.

4 Apparatus and materials

4.1 Printing device

4.1.1 To perform this test, use a printability tester with one or two printing units capable of applying a force (via a metal printing forme) on the printed sample independently from the preparation of the printed sample. The interval time may be defined by the printing speed (and the distance between units) or be adjusted by a timer.

Examples of commercially available printability testers that conform to these requirements are the prüfbau Multipurpose Printability Testing Instrument MZII,[8] IGT AIC2-5[4] or any compatible tester. A High Speed Inking Unit 4 is recommended for the IGT instruments while the inking unit is integrated in the MZII. Refer to footnote further down.

4.1.2 **IGT-type printing device** having a sector with a radius of (85,0 ± 0,2) mm, incorporating a facility enabling a packing (4.6) to be mounted under tension on the sector and a test piece to be mounted on the packing. The sector shall be capable of being driven over a distance of 200 mm at a uniform speed.

The actual speed shall not differ by more than 5 % from the theoretical value over the workable range as specified for the tester.

The force with which the printing forme contacts the test piece on the sector shall be adjustable. The actual force shall not deviate by more than ±10 N from the set force.

The printing device should be properly calibrated with regard to printing speed and printing force between the printing forme and the sector (see Annex A).

4.1.3 **Prüfbau-type printing device** having the possibility to run a substrate carrier, with a test piece mounted on it, with uniform speed under the printing formes.

The actual speed shall not differ by more than 5 % from the theoretical value over the workable range as specified for the tester.

The force with which the printing forme contacts the test piece on the sector shall be adjustable. The actual force shall not deviate by more than ±10 N from the set force.

The printing device should be properly calibrated with regard to printing speed and printing force between the printing forme and the sector (see Annex A).

4.2 Inking device

To distribute an even ink film of known thickness an inking device shall be used consisting of two or more inking drums having contact with a top-roller. The ink distributing surface area A of the rollers shall be known to the nearest 0,1 cm^2. Each inking arrangement shall incorporate one or more holders on which the printing forme to be inked in can be mounted.

The distributing surface area, A, is calculated as in Formula (1):

$$A = \sum_{n=1}^{n} (\pi \cdot d_n \cdot l_n) \quad (1)$$

where

d_n is the diameter of roller or drum number (n);

l_n is the effective length of roller or drum number (n);

n is the number of rollers excluding the printing forme.

NOTE The lifetime of the rubber or elastomer-covered parts is limited, if properly handled, to a maximum of approximately 3 years.

The transfer characteristics of rubber rollers can change by, e.g. using them for different applications, inks, bad cleaning, unsuitable cleaning solvents and ageing. If tests are made using different top-rollers, the top-rollers should be identical, and a test to determine the ink transfer might have to be performed.

4.3 Printing formes

4.3.1 For IGT-type testers, one or more aluminium printing formes, with known width and a diameter of (65,0 ± 0,2) mm and a temperature-insulating handgrip shall be used: one for the ink to be applied, and another one on which the set-off paper will be mounted. These printing formes shall be of the same type. See Figure 1.

4.3.2 For prüfbau-type testers, a rubber blanket printing forme of the width of the whole printing area and an aluminium printing forme with a smaller width than the blanket printing forme shall be used. The rubber blanket printing forme is used for printing and the aluminium printing forme is used for set-off counter printing. The prüfbau tester has a separate holder for the set-off paper so no wrapping of the set-off paper around the aluminium printing forme is needed. The area not counter-printed will be used for optical density evaluations of the original print.

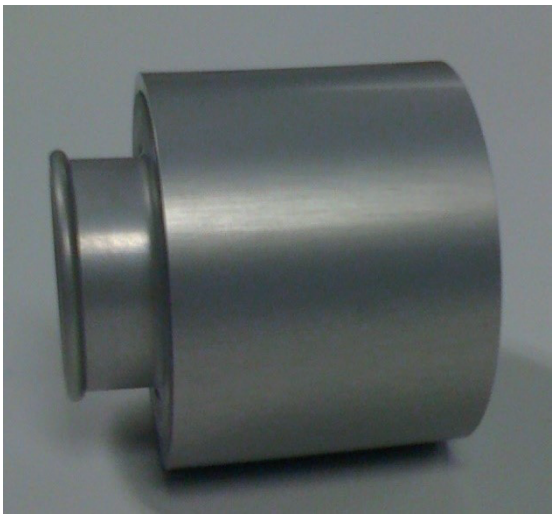

Figure 1 — Example of a printing forme meeting the criteria of 4.3.1

4.4 Ink pipette

To apply an accurate quantity of ink to the inking device an ink pipette having a minimum volume of 2 ml and a resolution of at least 0,01 ml, but preferably 0,001 ml shall be used.

NOTE 1 If the inking device is equipped with a dispensing system with sufficient accuracy, no ink pipette is needed.

NOTE 2 In principle, it is also possible to use the analytical balance to weigh the required amount of ink. In that case, the required ink film thickness can be calculated considering the mass density of the ink.

4.5 Packing

In general, backing materials shall be suitable for the printing forme type. In the IGT-type printability testers, rubber backing consisting of rubber blanket with a thickness of (1,70 ± 0,05) mm shall be used since aluminium printing formes are used to make this test.

Refer to the printability tester manufacturer's instruction manual to mount and adjust backing tension.

Over time, a rubber packing will deteriorate and in general get harder or get cracked. Also, dents can occur where smaller printing formes are used to over-print prints made with wider printing formes. In either case, make sure to replace the rubber before these effects take place. Annex B shows some of the possible defects.

4.6 Substrate carrier

A rigid carrier covered with a special rubber blanket with a thickness and hardness required for the used printability tester and for the used substrate thickness.

Over time a rubber will deteriorate and in general get harder or get cracked. Also, dents can occur where smaller printing formes are used to over-print prints made with wider printing formes. In either case make sure to replace the rubber before these effects take place. Annex B shows some of the possible defects.

4.7 Analytical balance

A balance with a capacity of at least 160 g and an accuracy of 0,1 mg at this weight.

NOTE Most modern analytical balances reach the specified accuracy only if after tarring the weight difference is less than 40-60 g.

Depending on the type of analytical balance and its sensor principle, some are sensitive to magnetism and others are sensitive to static upcharge. The printing formes should be demagnetized with steel parts and discharge printing formes with plastic parts.

4.8 Timer

A manual timer or stopwatch with a resolution of 1 s. Several testers incorporate automatic timing facilities.

4.9 Densitometer

A densitometer or spectrodensitometer in accordance with ISO 5-4. Other instruments with suitable discrimination of colour, optical density or other ways of reflection measurement, such as instruments in conformance with ISO 2469, can be used if results are suitable for the purpose.

4.10 Test paper

This test method is suitable for use with all papers used for offset printing. The paper strip shall be cut to fit to the used printability tester. The top or bottom, MD/CD and grain direction shall be chosen in accordance with the application and recorded.

4.11 Reference counter test strips

Cut to suitable size for the printability tester, commonly the reference paper as specified in ISO 2846-1 is used, commercially available as C2846[1) 2)]. The paper strip shall be cut to fit to the used printability tester. In case of other than the reference counter test strips the top or bottom, MD/CD and grain direction shall be chosen in accordance with the application and recorded.

4.12 Setting test ink

This test is suitable for use with all oxidative/setting printing inks intended for sheet-fed offset printing, in the paper industry this test is commonly executed with the (cyan) ink 404 520.068[1)] or 520068[2)].

In case of testing papers intended for heatset or coldest web printing, other inks might have to be used for representative results.

4.13 Cleaning

Use lint free towels and cleaning solvent compatible with the ink, the printing forme and the inking unit top-roller rubber materials.

After each test, clean all the inked parts of the printability tester and the inking unit with the cleaning solvent and towels. Dry the surface or give the solvent sufficient time to evaporate.

5 Test method

5.1 Principle

A sample of the paper to be tested is printed on a printability tester under standard conditions with a defined amount of ink. After a specified time, the printed strip is counter printed against a strip of unprinted paper: the set-off paper. Part of the ink situated on the surface of the printed strip will transfer to the set-off paper. The more ink is absorbed into the printed strip in a defined time frame, the less ink will transfer to the set-off paper. The optical density of the transferred ink on the set-off paper is a value for the absorption in the tested paper.

The test should be repeated at least 3 times per combination of ink and paper. Depending on the purpose of the test, different combinations of interval times should be used, e.g. 0,1 s; 0,4 s; 3 s; 10 s; 15 s; 30 s; 60 s; 120 s; 180 s and 240 s or very long times. These times can be timed automatically by the printability tester or by hand with an external timer or stop watch.

Different combinations of paper and ink for different user groups, e.g., paper industry, ink industry or printing industry/converters are covered.

The ink setting/ink absorption can be analysed by making a graph of the optical density of the set-off paper against the used interval times.

5.2 Test conditions

5.2.1 Climatic conditions

All equipment shall be conditioned at least 2 hours; tests shall be conducted under standard atmosphere; to most standards it is (23,0 ± 1,0) °C and (50 ± 2) % RH.

Papers and equipment should be conditioned during more than 6 hours but at least as long as needed to reach equilibrium.

Inks should be conditioned during more than 6 hours but long enough to reach temperature equilibrium for the type of package. In case of large packing, it is recommended to repack the ink for the test in smaller containers.

5.2.2 Settings of the printability tester

The printability tester shall be set to a printing force of 200 N/cm print width on both printing units and to a constant printing speed of 0,5 m/s.

The interval times shall be selected in accordance with the purpose of the test according to Table 1.

Table 1 — Interval time Settings

	IGT	prüfbau	Preferred intervals
Very Short time (one interval time)	0,014 to 1,0 s [a]	-	0,1 s
Short time (two interval times)	0,1 to 10 s [b]	-	0,1 s – 3 s
Medium time (four or more Interval times)	5 to 300 s	5 to 300 s	30 s – 60 s – 90 s – 120 s
Long time (four or more interval times)	30 to 1 000 s [c]	30 to 1 000 s [c]	60 s – 120 s – 300 s – 600 s

[a] One interval time per test, speed dependent, AIC2-5 only.

[b] Two interval times per test.

[c] Longer interval times, manually timed on some instruments.

5.2.3 Settings for the inking unit

Prior to the test, an amount of ink shall be applied to the inking unit using an ink pipette, the ink shall be distributed and applied to the printing forme homogenously using one section of the inking unit top-roller. To improve reproducibility, distribution and inking shall be done under controlled time and temperature so whenever available, the thermostat on the inking unit shall be used.

For best repeatability the ink can be applied using an ink pipette. This way, the ink is applied as a volume and the ink film thickness, I, in µm, is defined by Formula (2):

$$I = \frac{V}{A + A_p} \tag{2}$$

where

V is the applied volume of ink in ml;

A is the inked area of the inking unit from Formula (1);

A_p is the surface of the used printing forme in cm^2.

For print tests using production ink and production paper, the ink film thickness shall be in conformance with the application. This is in sheetfed offset commonly between 1,0 µm and 1,3 µm (about 1 g/m^2 to 1,3 g/m^2). For a maximum ink coverage of 300 %, this comes to 2,5 µm to 4 µm in case of multi-colour printing but with a drying time between the different colours and a back-trap effect.

For this reason, there are two options given for the ink film thickness during the test. Note that this refers to the ink film thickness on the substrate, while the ink film applied on the inking system is normally about double the amount.

To ensure the correct amount of ink on the substrate it is recommended to make weighed prints for determination of the exact ink transfer before starting the test. Once the ink transfer is known weighing is no more needed.

The Table 2 shows the inking unit settings for IGT-type and prüfbau-type instruments.

Table 2 — Inking Unit Settings

	IGT AE	IGT HSIU4	prüfbau
Ink film for single colour	2,4 µm	2,4 µm	2,0 µm
Ink film for multi-colour	4,0 µm	4,0 µm	4,0 µm
Starting time	-	5 s	-
Distribution time	90 s	20 s	30 s
Distribution speed	fixed	1,0 m/s	fixed
Inking time	60 s	30 s	30 s
Thermostat Setting	-	23 °C	23 °C

6 Procedure

6.1 Preparation

For the operation of the IGT-type testers, IGT AE inker, High Speed Inking Unit 4 and ink pipette follow the user manual and the IGT information leaflets W100 and W48. For the operation of the prüfbau instrument, see the manufacturer's user manual.

Handle the samples carefully, the printing area shall not be touched either before or after the print, to avoid finger prints and other defects.

Cut the paper strips for print and set-off to the proper size and mark them with top and/or bottom side, machine and/or cross direction and a code for the type of paper.

6.2 Preparational test for ink transfer determination

Make prints in accordance with the procedure described in ISO 2834-1 to determine the ink film thickness on the paper and adjust the inking level on the inking unit of either system to a level that 1 µm or 3 µm (about 1,0 g/m^2 and 3 g/m^2, respectively) are achieved on the paper.

For slow drying inks, such as the special setting test inks, it is possible to do this during the test as described in 6.3.1 and 6.3.2: weigh the printing forme before making the print and weigh it again after the print. Calculate the ink transfer and correct the ink volume if needed.

On some testers or printing formes, a small section of the print is not countered and it is possible to measure the optical density of the un-countered print. In these cases, the density of the different prints shall be adjusted such that it shall not vary more than ±0,05 Density units and should not vary more than ±0,03 D.

6.3 Test execution on different instruments

6.3.1 IGT-type testers

Depending on the instrument versions the procedure can differ slightly, consult the manufacturer's instructions in that case for details.

a) Mount the rubber packing on the sector;

b) Adjust the settings of the printability tester:

   1) printing force for both printing units to 200 N/cm[1] print width;

   2) select constant speed mode;

   3) printing speed 0,5 m/s.

c) where possible select a mode for 4 interval times, set the interval times according to Table 1, Medium Time; 30; 60; 90; 120 s; if not possible, make four prints, each with one of the times as specified. If one of the other sets is used record the times in the report;

d) Adjust the inking unit with the settings in Table 2;

e) Fill the ink pipette with the ink to be tested;

f) Attach a test strip on the sector;

g) Mount a strip of the set-off paper with a piece of tape at the beginning and the end of the strip on a clean aluminium printing forme;

h) Apply the amount of ink required for the ink film in Table 2 on one segment of the top-roller of the inking unit and distribute the ink;

i) Place the printing forme on the inking shaft of the inking unit and ink the printing formes during the time as specified in Table 2;

j) Take the printing forme from the inking unit, weigh it with an accuracy of 0,1 mg, tare the balance;

k) Place the printing forme on the top shaft of the tester;

l) Place the printing forme with the set-off paper on the bottom shaft such that a proper counter print is made without any relevant print on the tape. Turn the printing forme with the paper into the position that the beginning of the set-off paper points upwards;

m) Make a print;

n) Make four set-off prints at the selected interval times; In case of an AIC2-5, this implies that 4 prints have to be made and four set-off prints have to be made: g) to r) shall be performed four times;

o) Remove the printing forme and weigh it with an accuracy of 0,1 mg;

p) Remove the paper strip from the sector and the set-off strip from the printing forme.

q) Mark the strips with the set-off times and store them in a controlled place until the evaluation;

r) Clean the inked parts;

s) Repeat g) to s) 3 times for all selected interval times;

t) Make an accurate record of the conditions and the results of the test;

u) Wait 24 hours and measure the test result as described in the section “Assessment”.

6.3.2 Prüfbau-type testers

a) Select a carrier according to the substrate thickness;

b) Adjust the printing force for both printing units to 200 N/cm[1] print width;

c) Adjust the printing speed to 0,5 m/s;

d) Use interval times of 30; 60; 90 and 120 s;

e) Adjust the inking unit with the settings of Table 2;

f) Fill the ink pipette with the ink for the test;

g) Attach a test strip on the carrier;

h) Mount a strip of the set-off paper at the special holder for set-off paper;

i) Apply the amount of ink required for the ink film in Table 2 on one segment of the top-roller of the inking unit and distribute the ink;

j Place the printing forme on the inking shaft of the inking unit and ink the printing formes during the time as specified in Table 2;

k) Take the printing forme from the inking unit, weigh it with an accuracy of 0,1 mg, tare the balance;

l) Place it on the first printing unit;

m) Place the carrier left of the left printing unit;

n) Make a print;

o) Make the set-off print pressing the lever on the right side of the instrument after the set interval: the sample is moved forward about 25 % of the print. During this set-off print, part of the ink on the printed paper transfers to the set-off paper (the setting arm should be moved slowly but steady and prevent irregular movement);

p) Remove the printing forme and weigh it with an accuracy of 0,1 mg;

q) Remove the paper sample from the carrier and the set-off sample from the tester;

r) Mark the samples with the set-off times and store them in a controlled place until the evaluation;

s) Clean the inked parts;

t) Repeat g) to t) 3 times for all selected interval times;

u) Make an accurate record of the conditions and the results of the test;

v) Wait 24 hours and measure the test result as described in the section “Assessment”.

7 Assessment

In case of a four-interval times set-off print, the resulting prints will look as in Figure 2.

Figure 2 — Example of a 4-field countered print and its set-off print.

The top print is the original printed sample, the bottom image is the set-off print. The fields from left to right represent on the top image: original print, countered after 30 s, 60 s, 90 s resp. 120 s, and in the bottom image: set-off print after 30 s, 60 s, 90 s resp. 120 s.

NOTE On some modern instruments, a part of the original print is not set-off and holds the original ink film, this part of the print can be used to verify the density of the ink film, e.g. by measuring the optical density.

If a small aperture (spectro)densitometer is used measure and average at least 3 spots to 5 spots on each field. The average density is expressed as D_{p30}, D_{p60}, D_{p90} and D_{p120} of all fields in the original print and D_{s30}, D_{s60}, D_{s90} and D_{s120} on the set-off samples.

If a large aperture spectrophotometer is used, one measurement per field is sufficient. In this case the L^* value is used as measurement for all 8 fields and the "equivalent" of the optical density, $D_{(por s)(time)}$, is calculated as in Formula (3):

$$D_{(p\,or\,s)(time)} = 100 - L^*_{(p\,or\,s)(time)} \tag{3}$$

For each set of print-set-off print density, i.e. $D_{p(time)}$ and $D_{s(time)}$, the set-off ratio $S_{(time)}$ is calculated as in Formula (4):

$$S_{(time)} = \frac{D_{p(time)}}{D_{s(time)}} \tag{4}$$

These values can be entered in a graph for convenience.

8 Reporting

The report should contain the following:

a) A reference to this document, i.e. ISO/TS 19857:2021;

b) Any deviation from this test method;

c) Type of printability tester and inking system used and all its settings;

d) Used materials such as packing, carrier, printing forme;

e) Climatic conditions during the test;

f) Substrate (type, supplier, batch, mass per area, thickness);

g) Set-off substrate (type, face);

h) Ink (designation, supplier and batch);

i) Time interval between print and set-off print;

j) Table of results and/or graph;

k) Anything not specified in this document which might have influenced the result.

Annex A
(informative)

Checking the printing device and the inking device

A.1 General on calibration and instrument condition

A.1.1 General

Calibration of the printing device is very important for obtaining correct, reliable and repeatable results. For details on calibration, consult the supplier and the documentation supplied with the instrument. The items below are not meant as a guide to calibration but to give some information for consideration.

A.1.2 Force calibration of the printing device

— The printing force shall always be measured in a static situation. Never run the tester with the force calibration set mounted!

— Do not use a packing since deformation of the packing will influence the result.

— Make sure the contact line of the force is on the straight line between the centre of the sector or impression cylinder and the centre of the printing shaft. Any deflection will influence the result dramatically.

— On instruments with backlash compensation, set the backlash so that there is a 1 mm gap between the force-measuring device and the sector when the printing shaft is in the lifted position. This is not the position to make a print.

— If an original IGT Printing Force Meter is used, check whether the protective spring blade is in place. Without this protection, a dent will be caused in the sector.

A.1.3 Speed calibration of the printing device

— The best method is to measure the velocity on the circumference of the sector with its packing or on the impression cylinder.

— Use an aluminium printing forme at 350 N during calibration.

A.1.4 Checking the inking device

— Most inking devices do not need calibration but need proper maintenance.

— If a temperature-controlled inking device is used, the thermostat shall be calibrated regularly.

— Check that all accessories are mounted properly.

— Check that the top-roller touches the metal drums evenly over the full width.

— Check that the oscillating rollers move smoothly.

Annex B
(informative)

Visualization of defects of used materials

B.1 General

Figures B.1 to B.20 provide examples of possible defects of used materials.

B.2 Rubber packings

Figure B.1 — Dent due to different size of rollers

Figure B.2 — Contaminated packing

Figure B.3 — Cracks due to aging

B.3 Paper packings

Figure B.4 — Damaged surface, e.g. from adhesive tape

Figure B.5 — Dent due to not aligned rollers

Figure B.6 — Dents due to different roller sizes on the same packing

B.4 Substrate carriers

Figure B.7 — Dirt and tape on the back of the carrier

Figure B.8 — Dents, ink and markings on top of carrier

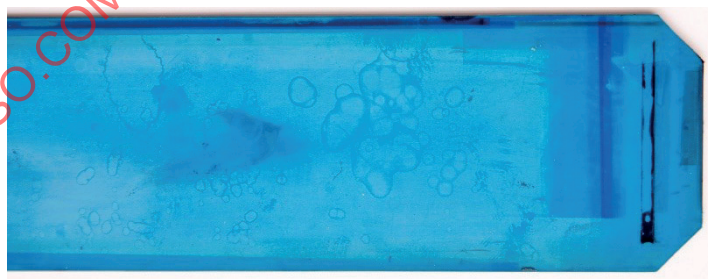

Figure B.9 — Carrier with dents used for different size rollers and different starting positions

B.5 Rubber rollers

Figure B.10 — Damaged coating due to local impact and wrong solvent

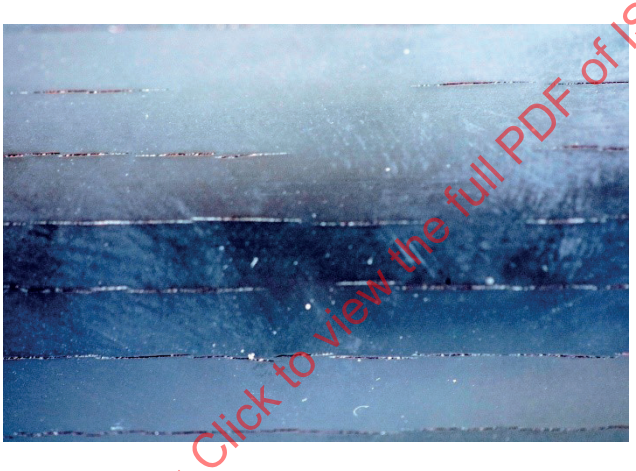

Figure B.11 — Damaged roller due to wrong solvent

B.6 Top rollers

Figure B.12 — Fully Glazed surface

Figure B.13 — Cracks due to solvent attack

Figure B.14 — Dent due to prolonged roller contact

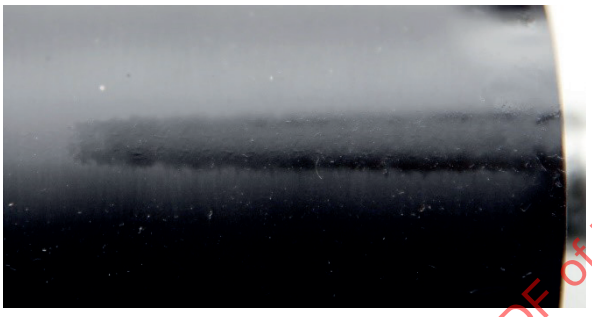

Figure B.15 — Dent due to roller contact with undissolved solvent

Figure B.16 — Pits due to local impact

Figure B.17 — Spot-contact damage