PSD
ProcessStandard Digital

Handbook 2022

Step by Step toward
Printing the Expected

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We would like to thank the members of the Digital Printing Working Group (DPWG). We would also warmly thank Color Alliance for provide parts of their "LFP Designer Guide" and PDFX-ready for the PDFX-ready guidelines V2.

New in 2022:

- Added latest Fogra standards (up to FOGRA60)
- Introducing Multicolour printing (ECG)
- Introducing RGB-based and ECG-based MediaWedge
- Added guidelines for 1D and 2D symbols (Barcode)
- Providing overview of historic PSD tolerance schemas
- Update of "PSD 2022" tolerances
- minor editorial changes

Changes made in the 2022 version are highlighted for easy review.

Member

Preface

Predictable Print quality for small and large format digital printing

Every print shop is committed to a high level of quality. A basic prerequisite for this is to use meaningful rules, hence a standard. In standardization a distinction is often made between the specification of the final aim and the needed (process) steps to achieve that aim. A good example for the latter one is the PSO - ProcessStandard Offset, which has been successfully in place for years.
For digital printing the PSD - ProcessStandard Digital now comes into play by providing industrial typical guidelines ranging from data creation all the way to printing. The focus of the PSD lies in the understanding and control of the entire workflow aiming for a predictable print result. In order to achieve this it needs both competent staff using appropriate instruments on the one hand and the interplay of important ISO, national and de-facto standards. So it is not one standard which takes precedence. Important standards must work in concert such as ISO 3664 for image appraisal, ISO 15311 for evaluating the quality of ink on paper, ISO 13655 for the colour measurements and ISO 14861 for high quality soft proofing.

The PSD has three main objectives.

1. Output process control – Achieving a repeatable print output
Different output processes will be checked against their known and constant behaviour. Here the PSD provides guidelines for ongoing process control by stipulating requirements for the needed quality reports.

2. Colour fidelity
The second goal addresses a consistent colour communication by means of faithful image reproduction. Guide by the motto: "Printing the Expected" quality oriented print service providers do first understand the needs and expectations of their clients and are second able to accurately reproduce that expectation. In that light the PSD extends the established way of colour reproduction namely the absolute reproduction ("Side-by-Side") by means of a all new media relative colour reproduction. Here the PSD provides the framework (spreadsheets and user guidelines) to evaluate print outs in a media relative fashion. In addition guidance is provided how to deal with spot colours and substrates with a high amount of optical brightener agents.

3. PDF/-X compliant workflow
Third, the entire workflow is subject to critical scrutiny as to its capacity for sustained achievement of consistent print quality and colour fidelity. Here PSD offers guidelines for creating, preflighting and processing PDF based documents.
Standardization does not mean that materials such as substrates, inks, toner or machinery must be limited. On the contrary, Fogra PSD aims toward a manageable facilitation of a material and process diversity in terms of rigours and consistent print quality. Only then is it possible to identify suitable "combinations", i.e. collection of a driving (RIP & colour management), a substrate, ink or toner and a printing press.

The PSD-concept is visualized in Fig 1.1.

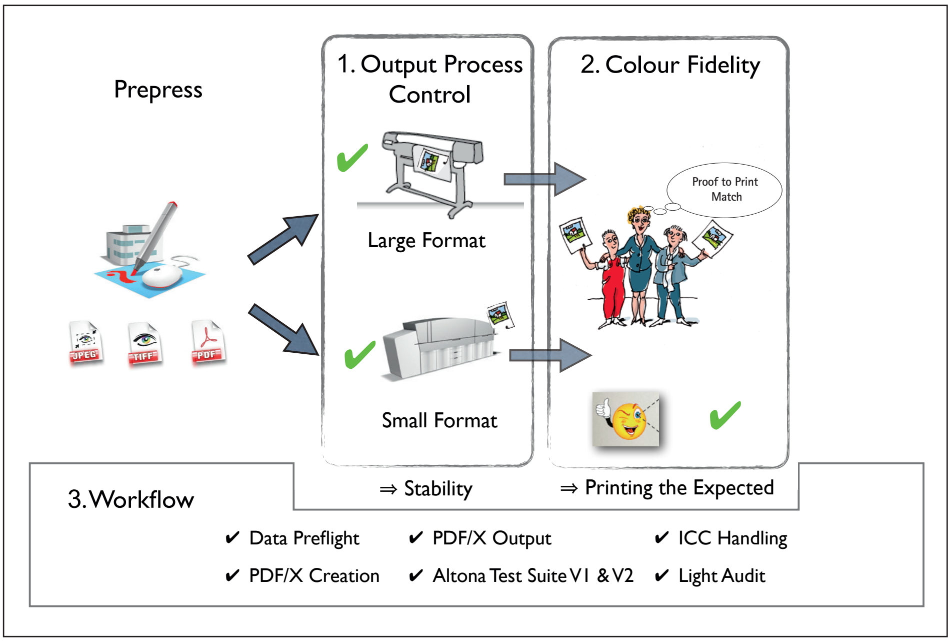


Fig. 1.1: Fogra PSD-concept. Aiming for a consistent and predicable print quality, the three aspects of output process control, colour fidelity and workflow need to be evaluated.

The publishing industry is constantly changing. New disruptive digital printing techniques enter the market, standards continue to evolve or to be revised; electronic media allows print service providers to become communication providers. That implies more complex processes and related interactions. To meet these changes the PSD is designed as a "living document".

Hint:
You are welcomed to print out the PDF file and put it inside a ring binder for easy access and replacements.

Intended audience

The ProcessStandard Digital is primarily aimed at print service providers active in the small and large format digital printing area. While the small format market covers both electro-photographic and (single pass) inkjet systems, large format (signage) printing (LFP) mostly uses inkjet technology.

Furthermore the PSD is aimed at print buyers in need of vendor neutral information about the strengths and weaknesses of digital printing processes. The provided industrial typical requirements and guidelines help to create print ready documents up front and to negotiate with the service provider based on informed decisions rather than on assumptions. It also helps to avoid unrealistic demands. All information defined in this handbook shall be considered as informative requirements and recommendations.

The PSD is currently not applicable for aspects related to AFP-based data, postpress as well as environmental and sustainability requirements.

Contents

1 Introduction

1.1 Process Control and Quality Assurance

An agreed minimum set of parameters is required to uniquely define the visual characteristics and other technical properties for the colour reproduction of a print product. It is therefore important that all individuals responsible for data creation, colour separation, proofing and printing operations agree on this set. This has been the underlying concept of ISO 12647 the multipart standard, which lists and explains the minimum set of primary process parameters required for process control. These requirements uniquely define the visual characteristics for specific processes such as lithography, gravure, flexography, or screen printing. This concept is the basis for 15311, however the parameters of the 12647 series, with the exception of parts -7 and -8 do not allow for clearly identifying primary process parameters that have a direct bearing on the visual characteristics of the image. Whereas part -7 and -8 of ISO 12647 specify requirements for contract proofing and validation print production systems, they refer to single-copies and do not provide specific criteria and requirements for digital production.

PSD on the other hand is process independent, in line with the move in the printing and publishing industries to use electronic data for content storage and data exchange throughout the print production process, from concept development to finishing. The economics of digital content creation and production preclude bespoke data preparation for all intended printing conditions, including analogue and digital processes. The final output conditions for print products, ranging from printed cups to large format banners, are often not known at the time of creation. Prior definition of expected image and product quality can be based on specific print image quality criteria. Guided by the motto "Printing the Expected" the concept of the PSD is based on a separation between process control and quality assurance.

Info:

ISO 8402:1995 defines quality assurance as: all those planned and systematic actions necessary to provide adequate confidence that an entity will fulfil requirements for quality. Both customers and managers have a need for quality assurance as they cannot oversee operations for themselves. They need to place trust in the producing operations, thus avoiding constant intervention.

Process control, as used here, covers all print specific settings and the corresponding visual and instrumental measures in order to establish a repeatable and stable printing condition. The process control measures therefore strongly depends on the printing technology and media used. Although process control is considered to be the responsibility of the print service provider some basic principles are important. They represent a change from traditional practices and are outlined in chapter 5.

Quality assurance, as used here, covers the evaluation of the printed matter. In other words what the client sees. Quality assurance measures reflect the provisions of the draft ISO 15311-2 for small format (commercial) and ISO 15311-3 for large format (signagne) printing. These criteria address colour rendition, homogeneity (uniformity), resolution, artifacts, in addition to permanence aspects such as light fastness or rub resistance. In order to address the different market needs the criteria and related test methods are evaluated with respect to three different quality types (currently termed "A", "B" and "C") .

1. Introduction

1.2 Colour Communication in digital printing

Colour accuracy or colour quality is typically related to almost anything with the term "colour" in its name. When talking about colour in the PSD it is the closeness of the visual match between a print and the reference printing condition. With respect to one-offs (single copy prints) ISO 12647-7 defines the stringent tolerances for the Contract Proof creation. This is often referred to as "Champions-League". The recently published ISO 12647-8 stipulates the tolerances for the so called Validation Print. To reflect this less stringent set of quality criteria it is termed "Bundesliga".
While for conventional printing the on-press proof was almost extinct there might be a renaissance in the realm of digital printing. This is the case since it is extremely convenient to use the same combination of materials for the reference print (Contract Proof, Validation Print or On-Press Proof) and for the production run.
Once the tolerances for how close to match the references are meet colour reproduction also relates to the closeness between that reference and the OK-print. Here PSD introduces the media relative colour reproduction (and viewing), which provides, together with the established absolute reproduction (viewed Side-by-Side), a modern framework for colour communication between print buyer and print service provider. In addition the proposal of a three level tolerance schema (quality types termed "A", "B" and "C") helps to identify the required level of colour match and to cover a wide range of printing application. Here the level "A" can be identified as "stringent" for colour critical applications; level "B" represents "normal" tolerances for industrial typical printing and level "C" is identified with "relaxed" tolerances.

It should be noted that the quality types "A", "B" and "C" should not be confused to interpret print products to be "better" or "worse". They are simply reflecting a identified "reference" implementation that happen to be identifiable by applying the collection of aim values and tolerances.

1.2.1 Requirements for colour reference visualizations

From on press proof to contract proof

Until the 1990s, the on press proof, aiming to simulate the visual characteristics of the finished print product as closely as possible, has been the most widely used means in order to create a colour reference. Such a proof showed a very good appearance match between the proof and the final production run, since most of the printing parameters such as plates, screen, paper and printing ink might be identical to those used for production printing. Only ink trapping sometimes caused differences between proof and print when flat bed printing units have been utilized in wet-on-dry printing.

Beside the conventional printing processes more and more photographic and toner-based imaging techniques such as Kodak Approval, FUJI Final Proof, Analog- and later Digital-Chromalin, 3M Matchprint, Coulter Stock LC Colourproofing and Iris Gaphics have been used for creating the so called digital proofs. The advent of these technologies was mostly driven by the cheaper price and the ease of use compared to the handcrafted creation of on press proofs. On and off press proofs basically serve the following needs:

¬ Colour reference for the printer and the print buyer
¬ Proof for suitable data preparation
¬ Reference in case of dispute

Quality control

In the light of the standardization mostly driven by the German Printing and Media Industries Federation (bvdm) and Fogra aim values and associated tolerances have been established for on press proofs. Basically, by tightening the existing tolerances for the production run this has been derived. Due to the lack of widely used and affordable colour measurement devices densitometric criteria, such as the solid ink density, tone value increase (dot gain), spread or the ink trapping was used. As useful the densitometrical evaluation has been proven to be for process control, it shows significant flaws in the colour match between two prints not being made up of the same constituents (ink, paper). For that reason, the visual match between the digital proof and the OK-sheet or the production run sometimes have not been perfect.

When is a digital print a proof?

The previously mentioned lack of colormetrical evaluations as well as the rise of modern and inexpensive digital printers, such as inkjet photo printers, lead to widespread use of overly colourful prints sent to the printer as the reference for the OK-sheet. The printer often failed to reach the required appearance; reclamation and rework have been the consequences. Though the question arose of how a digital print might be assessed on an objective basis in order to be a (technical realisable) colour reference for a given printing condition using a reasonable control element to be imposed on each document. This has been the hour of birth of the "Farbverbindlichkeit" - the colour reliability. Though the colour reliability is a property that has to be checked for each site or document separately. For that reason, a compact control wedge, like the Fogra MediaWedge CMYK, reflecting the trade off between a small size and a good correlation to the page content is essential for an easy assessment of the colour reliability. That automatically rules out test charts, such as the ECI2002, or charts testing the resolution or smooth vignettes for each print in the daily production. Such tests have to be scrutinized in the past by the means of the system or creation certification to be explained in the next paragraph.

A proof becomes a contract proof or a colour reliable proof only when certain criteria are met. The MediaStandard Print (MSD) published by bvdm, a technical specification and an accepted trade standard in the graphic arts industry, requires the Fogra MediaWedge, the compliance to colorimetrical tolerances taken from ISO 12647-7 as well as a complete human readable status line as prerequisites on each print. A label to be printed on each proof comprising the pertinent information often documents this. A colour reliable proof therefore guarantees that a printer, meeting the ISO aims, such as solid coloration and tone value increase curves derived by a suitable process calibration, can be assured that they can reach the given appearance by using the over and under inking capabilities of their press.

The role of the colour reliable proof within the workflow

Fig. 1.1 shows a simplified printing workflow consisting of a client, designer, production agency and print shop (printer).

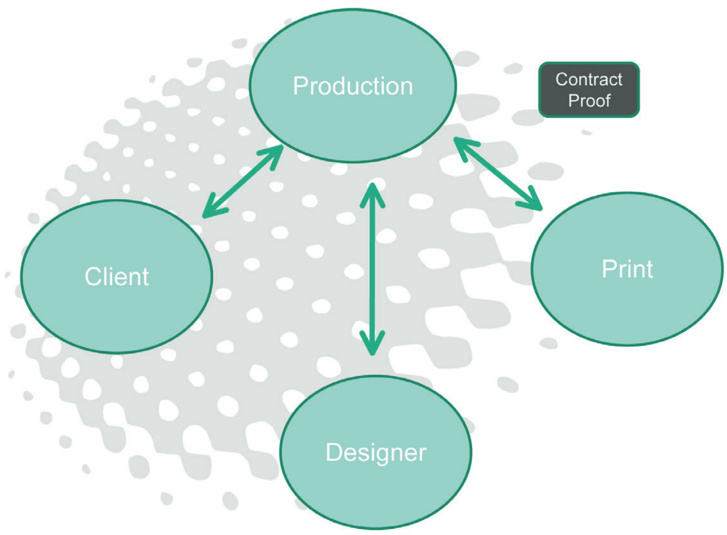


Fig. 1.1: The role of the contract proof within production workflows nowadays.

The colour reliable proof will mostly be used at the end of the creative work in the production chain. It shows the consistency of the data by giving the appearance to be expected when the printer prints according to the printing condition for which the data has been separated. In addition, it is the final place to see if something has to be corrected in the data. In that case, the data has to be corrected and is subject to be proofed again.

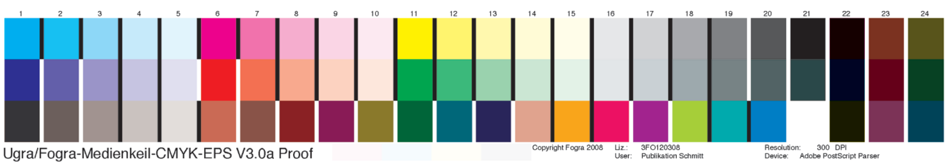


Fig. 1.2: Typical layout of the Fogra MediaWedge V.3. Most measurement and evaluation software is capable to read and evaluate the control strip. It therefore represents a versatile and flexible control wedge for CMYK based printing conditions.

Update

Overview of the Fogra MediaWedge family

The reference printing condition dictates the colour format of the control element to check the accuracy of a proof. Practically all printing standards used word wide are based on CMYK, hence four colour offset printing. In that light the control strip of choice was the popular Fogra MediaWedge CMYK V.3 as depicted in Fig. 1.2. It is also available with larger patch sizes typically required for printing processes with rough substrates and course screenings. Such processes can often be found in large format applications, hence the dedicated layout, see Fig. 1.3.

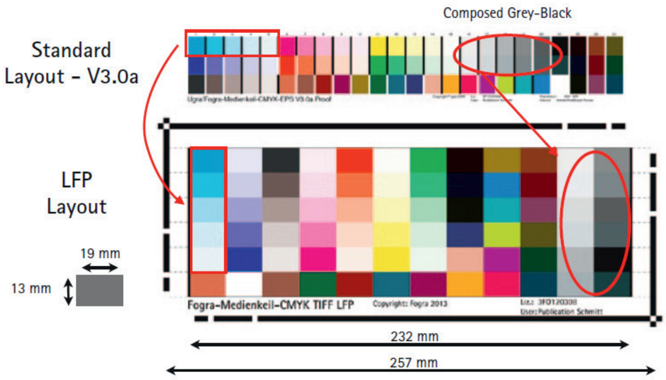


Fig. 1.3: Fogra MediaWedge CMYK LFP layout details. The current version is Fogra MediaWedge CMYK® V3.0 LFP V2.0.

The fundamental separation between sourcing and production is culminated by advent of exchange colour spaces. Those reference printing conditions are not reflecting a specific printing process but provide an overarching gamut that addresses the pertinent printing processes. For instances FOGRA59 was designed to cover both CMYK printing on offset and digital presses on coated stock. Based on recent Fogra research colour exchange spaces are also available for RGB-based printing conditions such as FOGRA58 (see Textile-RGB, Table 3.1) or CMYKOGV-based printing. In the latter case FOGRA55 was developed to reflect industrial typical ECG-7C printing on coated stock. In such cases the control element must also be available in RGB or CMYKOGV format. For photo and fine art applications Fogra MediaWedge RGB Photo V1 was developed, see Fig. 1.4 In that case the reference printing condition is typically the individual printing profile and the consistency of that printer is rigorously monitored over time.

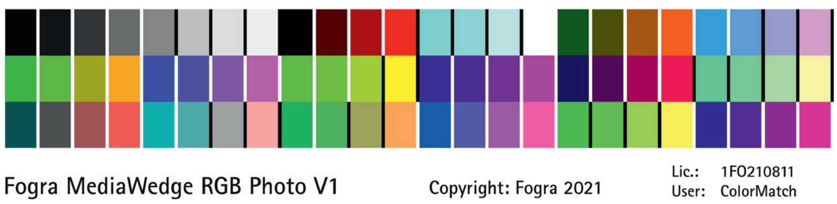


Fig. 1.4: Layout of Fogra MediaWedge RGB Photo V1 with 3 rows and 24 patches resulting in 72 patches

In case of textile printing large patch sizes and a more grid points, i.e. tone value combinations are needed. For modern textile based exchange colour spaces such as FOGRA58 Fogra developed the Fogra MediaWedge RGB Textile, see Fig. 1.5.

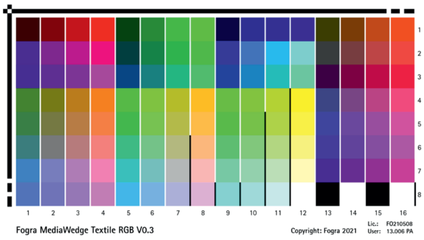


Fig. 1.5: Layout of Fogra MediaWedge RGB V0.3 beta version with 128 colour patches.

For Multicolour printing Fogra provides control elements for 5C, 6C, 7C and 8C printing, see Fig. 1.6. Here the tone value combinations are designed independent of the added ink. For instance Fogra MediaWedge Multicolor 5C can be used for CMYKO, CMYKG or CMYKV-based processes.
Although the specific tolerances for colour reliability in ISO 12647-7 and 12647-8 encompassing the traditional CMYK-based criteria, they can also be interpreted to be used for RGB or Multicolour printing.

Hint:
Check out the free spead sheets for evaluation colour accuracy of RGB-, CMYK- and ECG-based MediaWedges here: https://fogra.org/en/downloads/work-tools/process-standard-digital-psd

Update

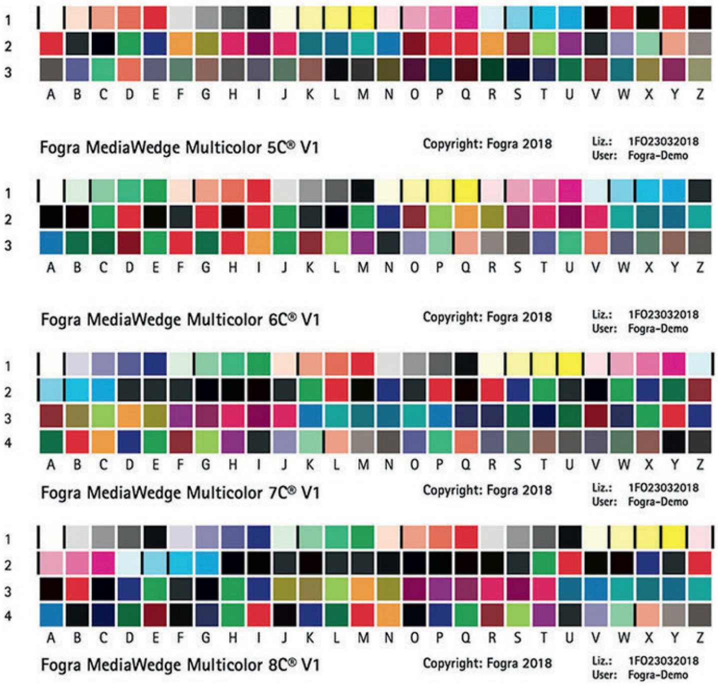


Fig. 1.6: Overview of Fogra MediaWedge Multicolor layouts. The picture shows exemplary colouration, e.g. the fifth colour in 5C MediaWedge is orange.

The „Validation Print" – The colour reference in the design stage

In light of the increasing demand of print buyers for higher quality and improving image quality of modern digital imaging devices, such as toner based printers, there has been a customer and industry need for a less stringent set of quality criteria. This „second level" should be used primarily in the creative process and reflects a high quality validation of the proposed job content. Here especially cost and time efficiency play an important role since

the contract proof is not always adequate at this early stage. The Fig. 1.2 illustrates the role of the so-called "Validation Print" in the colour and layout design stage of the production workflow.
A "Validation Print" is therefore a defined and reproducible quality within the creative phase and not primarily a colour reliable reference for the final production run. If prior agreement among all parties (client, printer and production) have been made even a "Validation Print" might be used as a colour reliable reference meaning that it represents the reference for the production and in case of a dispute. This might be the case if the production run is subject to be conducted using digital printing (e.g. using the same substrates).

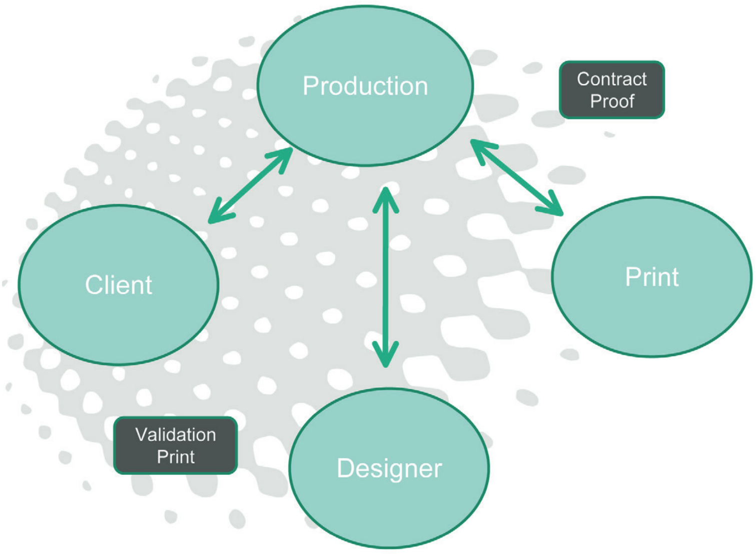


Fig. 1.7: Role of "Validation Print" and "Contract Proof" in a schematic production workflow.

Certification, ISO standardization and day by day production

The increasing number of incompatible proofing certifications across different markets and regions led to the cumbersome situation where manufacturers of proofing systems had to certify their system several times. Manufacturers therefore came to Fogra asking for the establishment of an international agreed upon standard stipulating objective criteria for the certification of a proofing system and the proof creation process. This goal was reached by the end of 2007 with the published standard ISO 12647-7 „proofing process working directly from digital data". The FograCert test procedures always kept track of the development by reflecting the ISO 12647-7 during that time. Here, the FograCert Contract Proofing System certifies the tested proofing system for the tested combinations of software, printer, paper and the printing condition to be simulated in compliance with the defined criteria. The FograCert Contract Proof Creation certifies compliance to the pertinent criteria within ISO 12647-7, and therefore, the ability of the proof provider to create contract proofs according to ISO 12647-7.
In 2006 the Japanese delegation brought up the discussion of the incorporation of second, less stringent level of conformance into ISO 12647-7. They provided concrete recommendations for certain requirements, mainly taking the existing ones with adapted tolerances and proposed to name that level "Design Proof". There was a strong feedback from a number of national bodies recommending not using the term "proof" in the naming of this second level – TC130 WG3 has later agreed upon the term "Validation Print". The second issue has been around the incorporation into the part -7 rather than to put it into a different part - ISO 12647-8 for example. Consensus has been reached by incorporating the Validation

Print into the existing part -7, not in the published 2007 version, but at the immediate revision of ISO 12647-7. This started immediately after the publication of the standard and it was recently published as a final standard. This has been done in order to avoid two almost identical standards. In order to reduce confusion between "Contract Proof" and "Validation Print", the status line (margin information) shall include the term "Validation Print according ISO 12647-8" or "Contract Proof according ISO 12647-7" respectively.

Colour Reliability of Digital Printing System and Digital Print Creation

As already described, ISO 12647-7 defines the process agnostic criteria for a certified contract proofing system as well as for the process of contract proof creation. However it does not explicitly define the colour reliability. Based on ISO 12647-7 and the MSP, the user finds a concise and stringent threefold hierarchy from the digital printing system (Contract or validation printing system) over the digital print creation process (Contract Proof or Validation Print) up to the definition of colour reliability. The tolerances have been summarized in Table 1.1.

Deviation tolerance	**Substrate**	**All Patches**	**All patches without the boundary patches**	**Near Neutral**	**Primaries**	**Primaries**
Contract Proof (ISO 12647-7:2016)	$\Delta E_{00} \leq 3.0$	Maximum $\Delta E_{00} \leq 5.0$ Average $\Delta E_{00} \leq 2.5$	–	Maximum $\Delta C_h \leq 3.5$ Average $\Delta C_h \leq 2.0$	Maximum CMY $\lvert \Delta H \rvert \leq$ 2.5	Maximum $\Delta E_{00} \leq 3.0$
Validation Print (ISO 12647-8:2021)	$\Delta E_{00} \leq 3.0$	–	Average ΔE00 ≤ 2.5 95th percentile ΔE00 ≤ 5.0	Maximum $\Delta C_h \leq 4.0$ Average $\Delta C_h \leq 2.5$	–	–

Tab. 1.1: Criteria of the Fogra MediaWedge CMYK V3 for colour reliability.

Hint:
ΔH will be explained in 2.3.2.

Update

Requirement	**Contract Proof according to ISO 12647-7:2016**	**Validation Print according to ISO 12647-8:2021**
Normative	¬ „Digital Proof according to ISO 12647-7"; ¬ File name; ¬ Digital proofing system designation; ¬ Substrate material type; ¬ The printing condition to be simulated; ¬ Time and date of production; ¬ Measurement condition: M0, M1, or M2	¬ „Validation Print according to ISO 12647-8" ¬ File name; ¬ Validation printing system designation; ¬ Substrate material type; ¬ The printing condition to be simulated; ¬ Time and date of production; ¬ Time and date of last calibration.
Optional	Colorant types; Colour management profile(s) used; RIP name and version; Scaling (if applied); Type of coating; Dedicated data preparation; Type of paper / structure simulation such as noise or patterning (if applied); Document ID (if a PDF/X document);	

Tab. 1.2: Required items of the status line.

1.2.2 Requirements for production printing

Concrete methods for evaluating colour rendering between an original and a reproduction are known since the publication of 1931 CIE standard observer - hence more then 80 years. With the presence of affordable colour measurement devices densitometry has been pushed back towards process control applications. This way of colorimetrically defining the closeness of a visual match was implicitly referring to an image appraisal that assumes a simultaneous viewing of both the original and the reproduction - placed next to each other. This way of appraisal is called "Side-by-Side". The plethora of devices and substrates in digital printing and the corresponding variety of use cases challenge that concept of colour reproduction/viewing. The most prominent nature of the absolute reproduction is the paper simulation, which is needed to compensate for the different paper shades. Such a paper simulation, however, is often not needed for many use cases or applications. Contrary often print products with a paper simulation are often refused by the print buyer. That is the case since the print product would never have seen direct next to the original in a "Side-by-Side" fashion. Hence print service providers are faced or demanded to switch off the paper simulation. The established "PSO-like" evaluation would most likely result in no conformance due to the colour difference in the paper colour.
For that reason, an old-fashion method, e.g. known from densitometry, will be used which normalizes or adapts for the paper colour. This approach is simplified by considering colours relative to white. Allowance is made for the fact that observers tend to perceive not in isolation but with reference to a framework provided by the environment. Such a framework is often the (unprinted) substrate. The media relative approach is intended for those applications where the final print product is subject for individual viewing or observation. It assumes that the observer fully adapts to the individual substrate what is practically the case for most not colour media. While keeping a certain level of predictability this media relative reproduction (and evaluation) is not applicable without limits. For instance it makes no sense to render from FOGRA51 ("coated offset") to IFRA26 ("newspaper printing"). For that reason there are details requirements for the source and destination gamut to make sure that both gamuts are similar in size and shape.

In the case when image content needs to be reproduce on a gamut that is substantially smaller than the reference large colour differences can be expected. These depend on the uses gamut mapping algorithm and the actual gamut differences. If gamut mapping algorithms are used that come from different vendors the reproduction might show significant differences. That is practically termed "not consistent".
This fact calls for another approach which allows for consistent rendering across different gamuts. Such an approach is termed "common appearance" and still an active field of research. It is planed to incorporate such an approach as soon there is enough substantiation for a practical, vendor neutral implementation.

1.3 Interfaces and Responsibilities

As already described, all of the guidelines and recommendations should be interpreted in an informative manner. Unless the criteria for the PSD certification are concerned (see chapter 8) there is no need to differentiate between a "shall" and a "should" - as it is good practice in ISO to clearly identify normative requirements (shall) and information recommendations (should).

The following table 1.3 identifies typical tasks together with the corresponding party being responsible for that specific job. It helps to clarify responsibilities .

Nr.	Task	Responsible	Note
1	Data creation – open (application) files	Print service provider should inform the data deliverer about the status of the data integrity.	Providing a reliable visualization e.g. by means of a hard- or softproof based on the corrected (optimised) data is needed for colour critical jobs.
2	Providing Print-ready data – marked as PDF/X.	Data deliverer	
3	Preflight of data	Print service provider	
4	Agreement and negotiation about the output condition (printing condition)	Print service provider together with the cli-ent (print buyer)	These include the definition of the quality type for CMYK (and spot if present), the intended viewing distance, the reference characterization data set as well as the colour reproduction („Side-by-Side" or media relative)
5	Printability of the substrate	Print service provider	Unless the manufacturer of the print-ing system has "certified" the pertinent substrate.
6	Process Conversion when data is not pre-pared for the intended printing condition	Print service provider	The print service provider is required to inform the print buyer about potential limitations preferably with a contract proof based on the re-separated data.
	... will be continued		

Tab. 1.3: Overview of typical tasks and related responsibilities for industrial typical production. The table will be continued in the course of time.

Proposal for a practical PSD compliant job sheet

A-Nr.	**135711**		**PSD Job sheet Template**
Last job		**12345678**	
Date	08.12.2016 - 08:57:41	**Digital Print**	Preference

Customer Customer-Nr. 12345	**Agency**	**Your Contact**
Smith Ltd Musterstr. 12 34567 Musterstadt Telephone: Contact:	Telephone: Contact:	Person in charge: Wolfgang Goethe Telephone: Mobile: Sales representative:

Run length:	**100**
Product:	**ProcessStandard Digital**
Format	150 mm x 210 mm
Number pages	Cover pages: 4 pages Content pages: 12 pages
Data and proofs	Print ready PDF-files and contract proof of pages 1, 13 and 15
Print	Cover pages: 4-colour (4/4-colour) Content pages: 4-colour (4/4-colour)
Colour Reference	FOGRA51 Quality Type: ☐ A ☐ B ☒ C
Colour Reproduction	☐ Side-by-Side ☒ Media Relative
Spot Colours	☒ Yes Quality Type: ☐ A ☐ B ☒ C ☐ No
Viewing Distance	☒ Standard (50 cm) ☐ Different: .... cm
Substrate	Cover: MultiArt Silk, wood free matt coated, 250 g/m² Content: MultiArt Silk, wood free matt coated, 150 g/m²
Post press	creasing cover, fold, saddle stitched with two staples, trimmed three sides
Packaging	Use card boxes
Delivery	Direct to customer
Please note: Prepress Imposition Schema	
Please note: Print	Colour reference for spot colour is sample provided by customer
Please note: Delivery to:	Deliver with additional job (Nr. xxx) Samplecity GmbH Musterstr. 12 34567 Musterstadt
Permanence	☒ Lightfastness according to ISO 12040 ☐ Other: ....

Schedule	**Date**
Data to print shop	
Print	
Delivery	

Hint:
This job sheet is only an example, which can be extended on an individual basis.

Material

☐ Paper ordered ☐ Paper at warehouse ☐ Paper by customer

Sheets	Sheets	Format	SG/LG	Description	g/m²	Cut to	Sheet
DB 1: SG 1: Cover (Digital): 4 Pages, 4/4 colour	20	1.000 mm x 700 mm	SG	MultiArt Silk	250	350 x 470 mm	80
DB 2-4: SG 2-4: 3 x Inhalt (Digital): 4 Pages, 4/4 colour	53	1.000 mm x 700 mm	SG	MultiArt Silk	150	350 x 470 mm	2

Print

Sheets	Machine/Press	Perfecting	Colours	Net sum	Gross	Result
02 - DB 1: SG 1: Cover: 4 pages, 4/4 colour	4607 - Nexpress 2500 4-colour	Yes	4 / 4	60	80	
03 - DB 2-4: SG 2-4: 3 x Content: 4 pages, 4/4 colour	4607 - HP 7600 4-colour	Yes	4 / 4	3 x 60	3 x 70	

1.4 Substrate choice defines the print output

The final print image quality is not only in offset printing significantly influenced by the used substrate. Therefore the title of the PSO chapter can be used here 1:1. Contrary to conventional offset printing according to PSO it is not possible to establish a group of representative papers or more generally substrates (known as paper types) that allow by means of basic optical properties the prediction of the final visual appearance (when printing with a predefined process). It is believed that due to the hybrid imaging technologies used for all kinds of digital printing scenarios a process or technology oriented classification seems inappropriate. It is not possible, as it was for conventional printing, to clearly identify primary process parameters that have a direct bearing on the visual characteristics of the image. Modern marking technologies are highly optimized for the interaction of colorant, substrate and the imaging process and can't easily be separated from each other.
For that reasons digital printing is not building "its own" printing conditions but rather start with fully characterized printing condition by means of a set of characterization data such as FOGRA51, i.e. offset printing according to ISO 12647-2:2013 on coated stock. Such a data set is called an exchange space when it happen to be used by many people for its appropriateness by means of a large but achievable gamut. The achievable gamut can generally be bracketed between cold-set printing on newsprint on the small end and by sheet-fed printing on gloss coated stock (in ISO 12647-1 referred to as paper type 1) or inkjet printing on are large gamut process on the large end.
The main benefit of such an exchange is twofold: On the one hand offset printers can use data prepared for this reference printing condition 1:1 while digital print service providers use colour management tools to re-separate (retarget) the data towards the actual printing condition. All offset related process information such as the paper type, ink sequence or the screening can be ignored. This is in particular helpful for hybrid jobs where prints will be produced with offset while a prior short run or some later comers are printed digitally. This workflow concept is illustrated in Fig. 1.3 and governed by the motto "Printing the Expected".

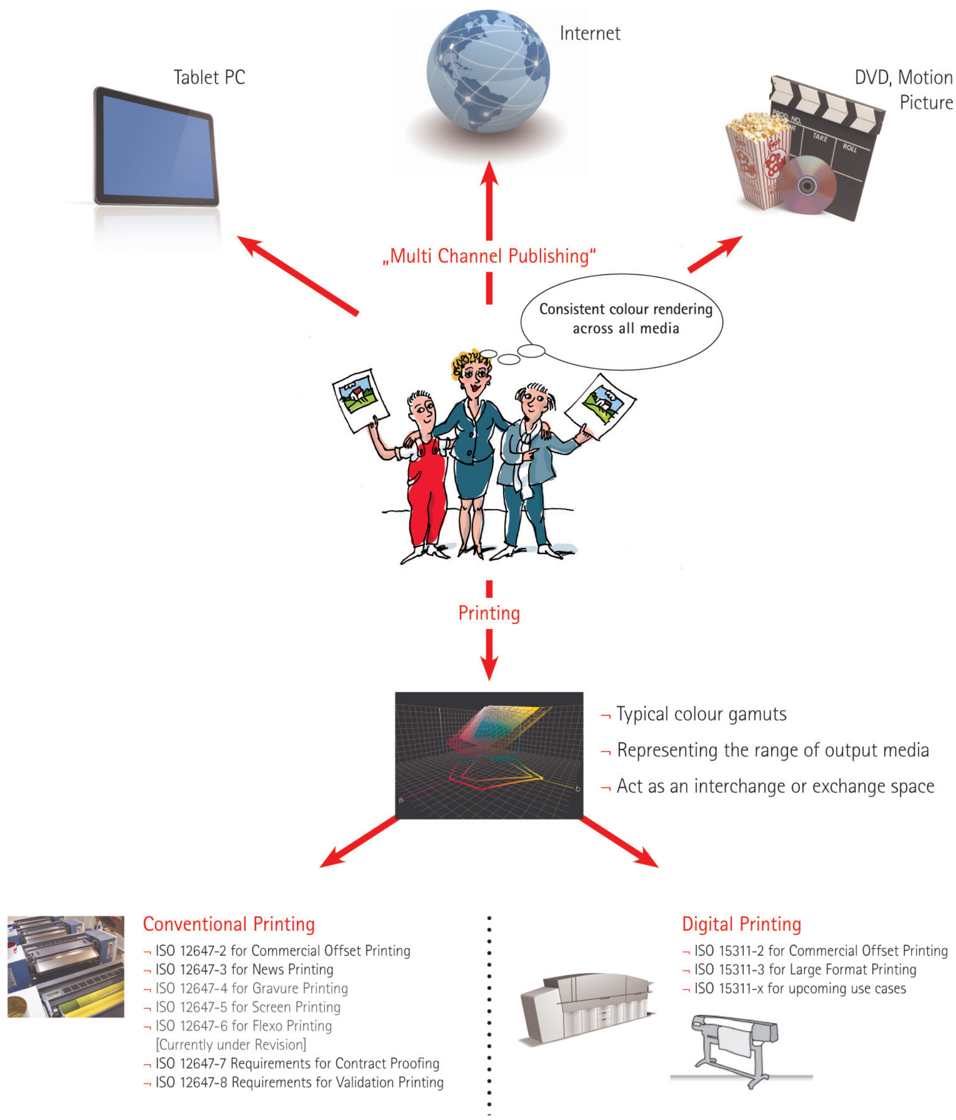


Fig. 1.8: „Printing the Expected“. Concept of the underlying idea to achieve a consistent image and colour reprodiction across different channels. Printing is only one channel and by providing a few exhcange spaces (to not confuse print buyers) it can be further devided into digital and conventional production.

The responsibility of the print service provider lies in the selection of an appropriate digital printing condition that is capable to closely match the gamut of the reference in a reliable fashion. Similar to offset printing the entire combination (interplay) of the paper, driving, print mode must be scrutinized with respect to it strengths and weaknesses. Such properties are :

¬ The reproducible colour gamut including the tone reproduction limits
¬ The gloss of the unprinted areas (in case of missing surface finish)
¬ The colour of the unprinted substrate
¬ Shine trough of a image printed on the back side or the backing
¬ Graininess, in particular that of the black colorant
¬ Production run stability

These parameters, except for offset printing, can't be deduced or estimated only by knowing optical and surface related substrate properties. They must be evaluated on an individual basis typically by test prints either done by the manufacturer or by the print service provider. Here manufacturers offer print media databases (alongside an ICC-printer profile) that help the customer to pick and to judge a paper that is suitable for the pertinent print job. Such an ICC-profile is wrongly termed "paper-profile". This term should be deprecated. However the printer should be cautious since many of the prescribed aspects can be deduced from the ICC-profile alone. In order to help a plausibility check is provided in the following clause.

Practical plausibility check of colour measurement values

The readings of a colour measurement, both for self luminous and reflective colours, strongly depends on the used geometry. That refers to the exact setup of the illumination and detection paths of the light. Primary parameters are the angle of the incident light, the size of the illuminated area and the observing direction (detector). Secondary parameters that might also be important are the aperture of the illumination and detection optics, field of depth and the degree of over- or underfilling.

Hint:

The „12-o'clock-test" is a practical test to check the sensitivity of a measuring device with respect to positioning. Here you place the instrument on a patch measure it and repeat this for 12 angular positions The variation of the 12 readings is indicates the influence of structured substrates on the measurement. It helps you to initiate corrective actions. .

In light of a measurement condition that reflects what we see (under average conditions) the 45°:0° (or 0°:45°) is the best compromise. For that reason that geometry is required (in ISO 13655 and ISO 5) for densitometry and colorimetry aspects in the graphic arts. The influence of the aperture will be obvious when viewing objects under a very tiny observer angle (as we typically do when using our eyes). The bigger the difference between the natural aperture of the human eye and the viewing aperture of the device the bigger the mismatch between the perception and the instrumental reading. This effect is quite negligible for isotropic substrates, i.e. surfaces that have a uniform reflection distribution function.
Using a plethora of new substrates such as textiles, plastics, ceramics, glass, metals etc in digital printing represents major challenges for state of the art colour measurements. Mostly the non-uniformity, i.e. structures and textures surfaces causes the aforementioned mismatches. E.g. for metallics the 45°:0° readings are not usable at all since due to the metallic reflection most of the incident light will be reflected in the mirrorlike angle and not to the sensor (placed at 0°). Thus the readings are much too dark. In that case a multi-angle geometry needs to be taken into consideration.
The usefulness of a print media (substrate) therefore can't be judged on a few optical properties alone. In other words the substrate manufacturer can't advertise it as "PSD compliant substrate". In fact a substrate needs to be considered as a part of a system combination that can be measured with existing ISO 13655 measurement devices in a way that plausible colour values can be achieved. For that reason a practical plausibility test was designed and will be mentioned in the following paragraph.

PSD Substrate conformance – Visual based plausibility test

Until there is an objective method to judge a substrate with respect to its printability and runability properties for a specific digital printing process the following visually based approach is recommended.

1. Assure printability and runability for the given combination (e.g. perform ink limit)
2. Print a test-chart with a layout and patch-size that can be measured with the pertinent ISO 13655 compliant instrument (e.g. iSis or iO from X-Rite, LFP from Barbieri, FD-7 from Konica Minolta or SpectroDens from Techkon). Print also the Fogra image quality testform (pages 1 and 2) and/or other DeviceCMYK test images of choice by using the same settings.
3. Print at least 5 times and repeat the measurements at least two times each.
4. Analyse the resulting measurement data with respect to outliers and spurious readings. Use the CIEA*b* spider web for assistance; it is depicted in Fig. 1.4
5. Create an ICC output profile ("Paper_test-XYZ.ICC") and save the measurement data in a separate ASCII file
6. Use a contract proofing system and create a new printing condition by facilitating the created output profile (or the ASCII measurement data) as the aim values
7. Proof the same data set (test chart and test images) according to the requirements of ISO 12647-7 by simulating the newly created printing condition ("Paper_test-XYZ.ICC")
8. Visually compare the original print out (step 2) with the proof print under norm light conditions (ISO 3664:2009).
9. Check if the measured colour differences on your proof (e.g. Fogra MediaWedge evaluation) do correlate with what you see. This is a subjective decision but based on your experiences it should be possible to make an educated guess about the suitability of the substrate. This check tells you if the ISO 13655 compliant readings are meaningful, which is the paramount prerequisite for "printing the expected".

In case your test fails, the used measurement solution (spot size, instrument geometry, software algorithms) can't be used in the context of the PSD to measure and mimic the pertinent substrate. Practically this restricts substrates to paper-like media where this tests usually is performed successfully. In case transparent substrates, measured on a white backer, pass this plausibility test, this substrate can be used in the context of the PSD. Due to the lack of agreed upon viewing conditions for backlit applications there are currently no provisions for such materials. However, the principles of the PSD can be applied in general to all other media.

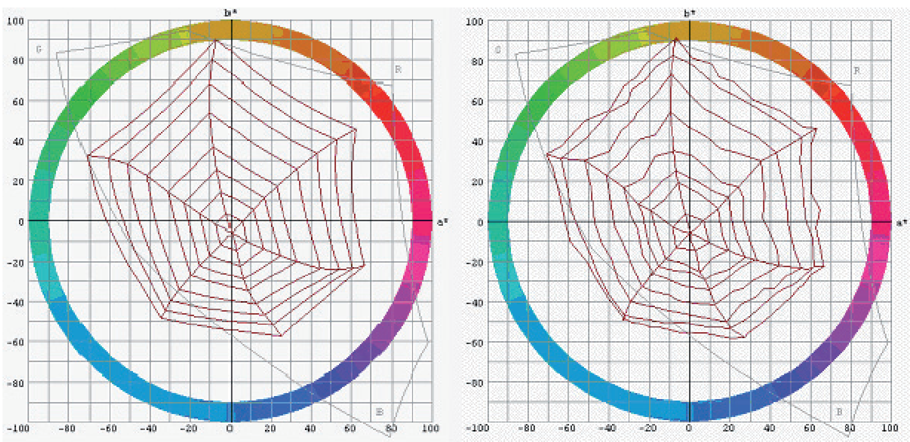


*Fig. 1.9: CIEa*b* spider-web diagram. Left: Perfect printing process. Right: Noise and erroneous data.*

On-Press and Off-press substrates – Is the difference needed?

Due to the limited printability of production (e.g. offset) papers to be used with state of the art inkjet proof printers, a clear separation between "proofing substrates" and "production stock" was required to express the differences.
It seems that this differentiation will be needed for the near future; however the raising level of colour accuracy of modern digital production machines provides the ability to create the colour reference (either a Contract Proof or a Validation Print) with the same substrate as the one that will be used later for production. In particular that might be the case for Validation Print that has the potential to become the "new" on-press proof. In that case the customer can predict the final appearance of the print product not only by means of the colour accuracy but also for related properties such as haptic, opacity and differential gloss.

Summary: The substrates determines both the final print quality and the achievable permanence and durability. It is the governing factor of the individual system combination, which unfortunately can be grouped or categorized as it was possible for offset printing.
It is the responsibilty of the print service provider to select the appropriate substrate.

Practical recommendation for media selection

1. The intended production substrate should be communicated clearly between the print service provider and the print buyer. The definition of a paper type (e.g. coated paper) is not appropriate for high quality print jobs. (See job sheet for more information).
2. When an additional surface finishing is planned it should be clearly communicated both in the job sheet and in the slug line (status information) of the Contract Proof or Validation Print to indicate if the colour reference reflects the printed product before or after surface finishing.
¬ In case, for whatever reasons, the production substrate differs from the intended substrate a print media should be selected that resembles the intended one by means of gloss, paper colour and coating.
3. If not defined otherwise a white backing should be used for all colour measurements (quality assurance).

2 Basics

2.1 What is colour?

The term colour is used quite differently in general usage. Contrary to the German language, where colour is unfortunately used for both the colorant and the perception, the English language suitably differentiate between paint (as the colorant) and colour as the perception. However colour is often wrongly referred to as a property of an object such a "green apple". This makes precise colour communication harder and was already noted by Yule:

„Colour was an art long before it was a science, and consequently the language of colour is poetic rather than factual."

– J. A. C. Yule, Principles of Color reproduction, 1967

Speaking scientifically about colour there are four different approaches that help to categorize and understand the different motivations and circumstances:

- To study the anatomy, physiology and diseases of the eye (Ophthalmology). In other words the psychophysical relationship of the human visual system with respect to colour vision e. g. Colour deficiency or colour blindness.
- To study the physical mixing of colorant objects to generate a required coloration e. g. ink formulation.
- To study the pleasing affective response (harmony) of colours interacting with each other
- To study the perception of the colours as to how the human visual system reacts to a given physical stimulus (Basic and higher colorimetry)

The Fogra PSD uses the term "colour" only by means of the last aspect namely as an attribute of the visual perception consisting of any combination of chromatic and achromatic content. Colour should not be confused with the physical stimulus (i. e. the visible radiation that enters the eye) that causes the sensation.

Generally there are four governing factors that contribute to the final colour appearance of an object colour, i. e. colours perceived to belong to an object. Firstly it is the spatial and temporal surround. This includes simultaneous and successive contrast phenomena. Secondly the surface characteristics play an important fact since they determine the gloss. Existing methods such as the TAPPI 75° method only allow for a indication or an increasing or decreasing gloss intensity but not an absolute description. Nor do existing reflection based gloss meters explain effects such as differential gloss or distinctness of Image. The third area or factor is the texture of a sample. Last but not least the translucency must be measured appropriately in order to estimate its contribution to the overall colour appearance.

These four general factors are visualized in Figure 2.1

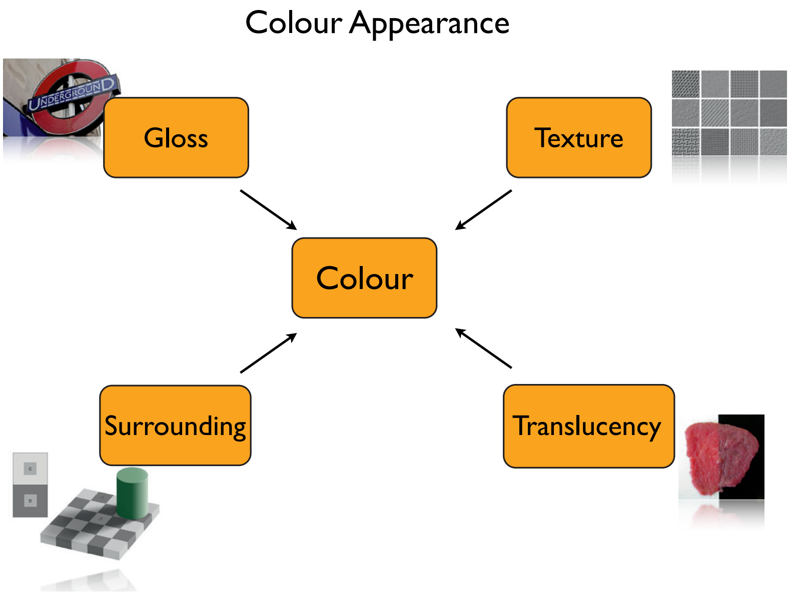


Fig. 2.1: Schematic view of the contribution of four elementary factors to the final colour appearance.

It is true that a colour is unambiguously defined by three figures such as CIEXYZ or CIELAB, but only under the specific measurement and viewing conditions. The most important influential parameters are the illuminant and the observer. The graphic arts industry uses for a variety of (good) reasons the CIE 1931 2°normal observer and the CIE D50 illuminant. This is also stipulated in the relevant ISO standards such as ISO 3664 for viewing and ISO 13655 for measuring. It must be noted that the afore mentioned unambiguous definitions only refers to objects that are perceived structure-less, opaque, free of fluorescence and seen with a adapted eye in a neutral grey surround and background. If theses assumptions are not met, the straight forward application of colorimetry is compromised.
Many print products can be well characterized colorimetrically under these circumstances. However there are applications and uses cases where the contribution of the factors shown in Figure 2.1 come into play. For instance the colour saturation of the underground sign significantly differs due to the different gloss levels (see top left). In light of the plethora of substrates used in digital printing this is a great challenge for the nowadays colour management.

2.1.1 D50 or D65, that is the question!

There are only a few topics that give raise to so much debate as the choice of the right illuminant. Contrary to the TV-, paper or textile industry, which are using D65 as the reference illuminant, the printing industry is seeming to go its own way. This parapgraph explains the background for that decision and discusses the consequence of a thinkable change toward D65.

The importance of the correct viewing conditions

The illumination plays a vital part when assessing colours between an original and a reproduction. Here both the spectral power distribution of the pertinent light source [over the visual wavelength ranging typically from 380 to 730 nm] and the state of visual adaptation determine the resulting colour appearance. The latter is basically governed by the entire field of view and most strongly by the immediate surround extending the objects to be appraised. Based on the principle transmission or reflection properties of the samples to be evaluated there are basically two different types of viewing conditions: Viewing transmissive media and Viewing reflective media.
Typical transmissive objects are photographic transparencies while colour reflection artwork as well as reproductions such as proofs or production prints (press sheets) are typical candidates for hardcopy material. In the light of internationally agreed upon (standardized) way of colour appraisal, e.g. for image and colour quality evaluation or critical comparison of prints and transparencies, a common set of defined viewing condition parameters is strongly required. One of them is the reference spectral power distribution which plays also a vital part in other important processes such as data preparation (e. g. via ICC Colour Management) or colour measurement.

The quest for the right colour temperature

The current practice of colour appraisal is marked by a significant decline of transmissive media to be used as typical originals. The direct comparison of such transmissive media (e. g. slides) against the printed reproductions was the main reason for internationally agreeing on the warm white CIE D50 daylight illuminant in 1974 (ISO 3664:1974) [xx]. This consensus was the result of important compromises which will be explained in the following section.
Photographic transparencies are mostly balanced in a way to exhibit a neutral colour appearance when illuminated by a tungsten projection lamp. Those kind of light source usually having a correlated colour temperature (CCT) ranging from 2800 K to 4000 K. The correlated colour temperature is the temperature of the Planckian radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions. For that reason such a "CCT-range" was a reasonable choice for typical viewing application. Contrary to transmissive media a viewing apparatus was not necessary for judging press sheets or proofs. Therefore it was common to assess the prints at the north side of the building which resembles a natural daylight phase to some extent. Anyhow it is known that phase of natural daylight are far from being constant; they vary dramatically with local and temporal changes. Typical daylight phases have been defined by the CIE (CIE - Commission Internationale de l'Eclairage), see Fig. 2.2. They are characterized by their correlated colour temperature such as D50, D65 or D75.

Fig. 2.2: Identical hardcopy prints under three different light sources (left: office illumination – „ Cool white Fluorescent", middle: daylight simulator D50 according ISO 3664, right: tungsten source)..

It should be noted here that a light source refers to the physical photon emitter while the illuminant refers to tabulated data. Because it is very difficult to produce artificial light sources of illumination which closely match the spectral power distribution of CIE daylight phases, it is important that the light sources used in the pertinent viewing cabinets (daylight simulators) show conformance to the criteria stipulated in ISO 3664.

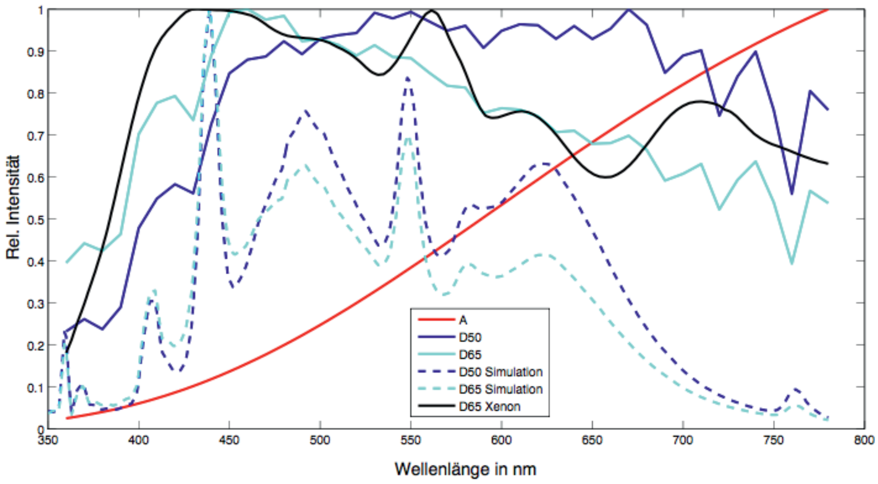


Fig. 2.3: CIE-daylight phases (solid line), simulators using discharge lamps (dashed line) and simulator using a xenon lamp.

The paramount reason for using daylight is, that it is usually perceived to be more neutral compared to objects illuminated by tungsten light sources. In addition a higher contrast is perceived using daylight illumination especially for colours absorbing in the blue spectral region such as yellows. A direct comparison between D50 and D65 with respect to the maximum colour differences between the adjacent tone values shows slight advantages using D50 for cyan and magenta colours. The differences for other colours have been found to be not significantly different from each other. In that experiment spectral reflectance curves of the primary and secondary offset colours have been facilitated by means of the CIE1976 and CIEDE2000 colour difference between tone values that differ about 1 %.
Having this scenario of two different correlated colour temperatures (approx. 3000 K [x] for transparencies and aprox. 6500 K for prints [x]) the compromise was reached by agreeing on an average colour temperature of 5000 K. This was necessary since the visual adaptation of the eye needs a stable reference; a direct comparison (short term memory matching) of two images with different "white points" causes significantly different perceptions.
Though print shops weren't forced to install two different types of lamps in their prepress and press rooms. The already mentioned industry branches such as the textile or automotive industry weren't faced with those compromises and have been working with D65 for years.

So why not change to D65 when there are no transmissive media anymore?

In the light of the decline of transmissive media in prepress work the before mentioned compromised loses its justification. A potential change toward D65 as the reference illuminant for the printing industry must be seen with caution. This is due to a plethora of consequences that will be outlined exemplary here:

- ¬ Extensive investments will be required for the established viewing apparatuses
- ¬ Revisions will be necessary for ISO standards with respect to aim values
- ¬ Modification of established documentation base (best practices, quality management documents, guidelines, characterization data, spec sheets etc)
- ¬ Enormous effort for communication and seminars needed
- ¬ More problems when matching samples with less (e.g. proof) and high amount of optical brighteners agents since the higher amount of UV leads to a higher excitation.

Working with D65/10°

Although the reference illumination remains D50 there are many use cases when clients specify the requested print using D65/10°. That can be the case for apparal textiles or typical industrial applications. For such cases there is currently no industrial common practise. For each individual case a dedicated solution needs to be found – starting from colour vierwing over colour measurements until profile making and quality control. In case of fluorescent samples it will be even harder since the UV amount of the light used for measuring and viewing should closely match that of D65.

2.2 The importance of the right illumination

Print products will be observed and judged under different illumination levels and types. The perceived colour strongly depends on the light hitting the object to be viewed. The resulting effect depends on the interaction of the spectral distribution of the incident light and the spectral reflection factor of the object. Only when agreeing on a reference (standard) illumination a global colour communication is possible. For the graphic arts industry this was defined to be D50, see last paragraph 2.1
When fluorescing objects are of concern, that is true for all papers containing optical brightener agents, not only the spectral distribution of the incident light in the visible but also in the UV-region plays an important role.

More information can be found at Fogra Extra No. 18

2.2.1 The ISO standard for image viewing

The active participation of manufacturers of standard light booths on the revision of ISO 3664, specifying tolerances for artificial sources of illumination which closely match the spectral power distribution of natural daylight (D50), resulted in equipment that met the stringent criteria of conformity 2009 shortly after its adoption. This third edition cancels and replaces the second edition (ISO 3664:2000), which has been technically revised by tightening the compliance tolerances on the UV portion of the standard illuminant D50 spectral power distribution. The replacement of the old tubes with the new ones, including suitable modification of the apparatus itself (reflectors, diffusers, etc), is more and more replaced by installing LED based light cabinets. New LED technologies allows to further reduce the tolerances to improve colour appraisal in the future. That step is one part of many others such as including a D50_noUV (to be called "P3") viewing condition in the currently started revision of ISO 3664. Stay up to date by reading the Fogra ISO news!

Hint:
Here you can find an excellent article from Konica Minolta describing the measurement and viewing conditions M0, M1, M2 and M3: https://myiro.com/en/blog/iso-136552017-demystified.

Align measurement and viewing conditions & OBA amounts

There is no doubt that the best viewing condition for the visual assessment of colour is that in, which the product will be finally seen. The approach of the printing industry is to first determine a suitable standard light source (such as D50) and then they match the spectral power distribution as closely as possible. If the light source used for measuring graphic art specimens also matches the spectral power distribution the provisions are made for a consistency between measurement results and visual assessment. ISO 13655:2017 provides for colorimetric measurements under several spectral conditions. One, identified as M1, has the similiar spectral power distribution as D50 and samples deemed to match colorimetrically under that measurement condition can reasonably be expected to match visually ISO 3664:2009 compliant viewing cabinets.

Classification	Description of OBA
$0 \leq \Delta B < 1$	Faint (Fogra recommendation: "No practical relevant OBA")
$1 \leq \Delta B < 4$	Faint
$4 \leq \Delta B < 8$	Low
$8 \leq \Delta B < 14$	Moderate
$14 \leq \Delta B < 25$*	High

Tab. 2.1: Levels of OBA according to ISO 15397. For practical purposes it is recommended to provide an additional category for $\Delta B \leq 1$ reflecting no or practically no OBA.

Therefore it is important to check the OBA amount of your production stock as a reference for choosing your proofing paper. There are two practical means to measure the OBA-amount of a sample. First the difference of ISO Brightness with and without UV excitation, called DB. Secondly the difference of CIEb* values when measured with UV (e.g. M1 or M0) and without UV (M2). Typical values for practical relevant amounts can be seen on the right table. BTW, the Fogra proofing paper database provides the information of the OBA amount for all tested substrates!

ΔB	0	2	4	6	8	10	12	14	16	18	20	22	24
ΔCIELb*	-0.3	-1.2	-2.0	-2.9	-3.7	-4.5	-5.4	-6.2	-7.1	-7.9	-8.7	-9.6	-10.4

*Tab. 2.2: Relationship between ΔB and ΔCIEb*M1,M2 for practical evaluation. As a rule of thumb the ΔB-value can be halved and marked by a negative sign.*

Colour transformation for substrates with different amounts of optical brightening agents (OBA)

The reproduction of pictorial originals on media with different amounts of optical brightener agents (OBA) and paper shades, still poses a great challenge to prepress companies and print service providers. While the colorimetric match works well for media with similar paper shades (CIELAB value of the unprinted paper) and similar amounts of OBA, the situation is significantly different for different white points and OBA amounts. The simultaneous appraisal of two originals with different paper shade and OBA amounts leads to a complicated visual matching situation. On the one hand this is due to the different colour adaptation due to the sometimes very different white points of the motifs or motif areas in the field of view, and on the other hand to the UV amount of the viewing booth, which stimulates the brighteners and thus leads to a more or less pronounced blue shift.

TIP

Fogra Extra 42

Investigation of colour transformation for substrates with different amounts of optical brightening agents (OBA)

Although that situation is not recommended it cannot be avoided in some practical situations. The interested reader can find more information on the Fogra website (see Tip). Some general recommendations that reflect the current state of research are summarized here:

- The use case must be clearly communicated. Colour matching for print evaluation per se (without reference) can lead to unusable results for a side-by-side comparison if a paper relative conversion (such as relative with black point compensation) is used,
- The best visual matches are obtained in a side-by-side comparison if the grey axis is converted "absolutely" over a wide lightness range, i.e. in the present case of the a*b* neutral reference (Hemp), the grey gradient is also more CIEa*b* neutral. In this case, no break-ups may be produced by too strong a "fan-out" onto the paper tone,
- In principle, the use of a perceptual rendering intent with rather paper-absolute gamut mapping is to be assumed as a suitable adjustment method for media containing brightener,
- The rendering intent "Relative with black point compensation" must be used with caution and only with prior checks,
- Check the amount of UV in the standard light booth with the Fogra method,
- The more UV the bluer or more lilac the paper and the more yellow must be used for compensation in terms of absolute grey adjustment, i.e. with CIELAB colour values close to the CIEa*b*= 0 axis. If the amount of UV in the booth is too low, the use of M0 leads to a visually better match.

TIP

Fogra Method to compute UV-content: https://fogra.org/en/downloads/work-tools/softproof-lighting

2.2.2 The metamerism phenomenon

As prescribed in the previous section the appearance of a surface colour is influenced by the illumination. The following paragraph provides information and practical guidelines for an important aspect of colour rendering, which is often confused. We talk about metamerism.

What is „metamerism"?

The terms „metamerism" originates from Greek and refers to equality under certain circumstances. When comparing a yellowish paper with a white paper under a yellow light both papers match. Changing to a white illumination the appearance changes to the "normal" state, i. e. the white paper appears "whitish" and the yellow one "yellowish". The effect that two different objects, i. e. samples with different spectral reflectance factors, match under one light source and fail to match under a different is called metamerism. The two samples are called "metameric samples" or "metamers".
Two specimens having identical tristimulus values for a given reference illuminant and reference observer are metameric if their spectral radiance distributions differ within the visible spectrum. The procedures concerned with a special metamerism index for a change from a reference illuminant to a test illuminant of different spectral composition, or that for a change from a reference observer to a test observer of different colour-matching functions are called the determination of special metamerism indices.

EXPERT

Metamerism is caused by the fact that the human visual system is comprised of three different receptors (that project the high dimensional spectral reflectance space onto three dimensions)

Metamerism – change in illumination (M_{ILM})

This procedure defines a special metamerism index Milm for a change from a reference illuminant to a test illuminant of different spectral composition. It must be noted that the metamerism index M_{ilm} is not suitable for determining the resultant colour shift or specifying the colour constancy of a single object colour when the illuminant is changed. That will be explained later. Figure 2.4 shows typical light sources.

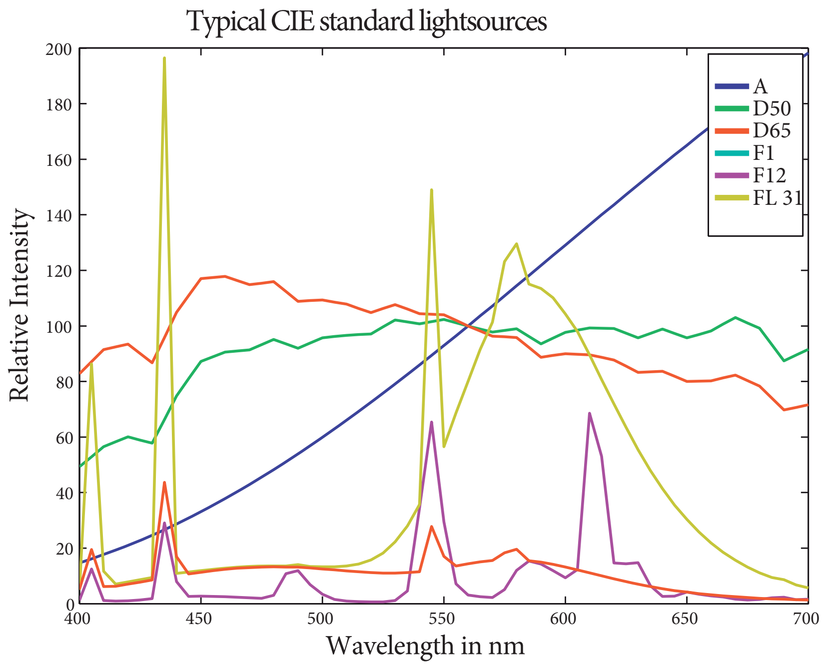


Fig. 2.4: Standardisierte Lichtarten der CIE.

Metamerism – change in observer

Observer metamerism represents the case where one observer see a visual match between two samples and another doesn't. The CIE 1931 and 1964 standard colorimetric observers represent the colour vision properties of the average population reasonably well. Nevertheless it is well known that individual deviations in the colour-matching functions occur among colour normal observers. Hill provides a set of 24 colour matching functions that show the variability among persons with normal colour vision, see Fig. 2.5. They contain both the CIE 1931 2° and CIE 1964 10° standard observer. Observer metamerism is not restricted to "human observers". It can also be computed for cameras which have camera spectral sensitivities instead of cones or colour matching functions.

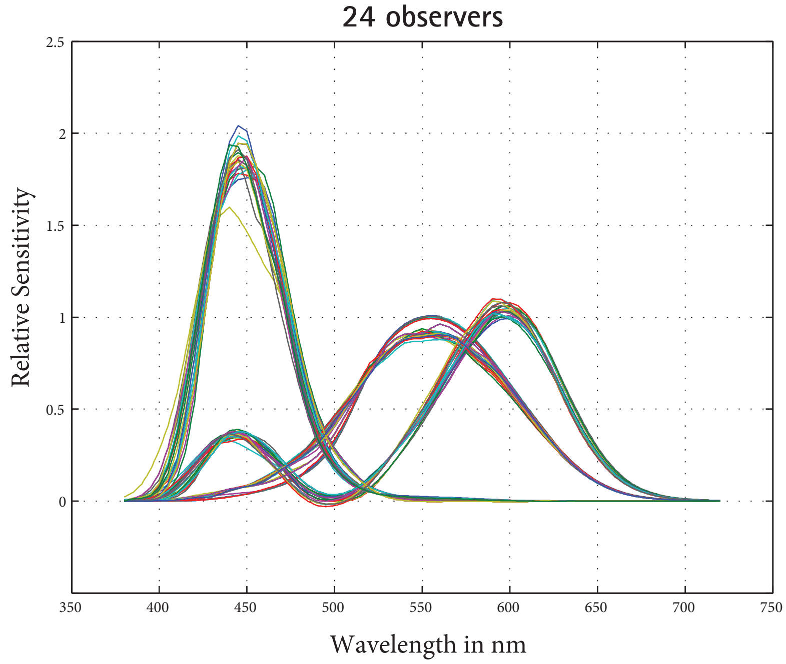


Fig. 2.5: Set of 24 representative observers (colour matching functionn) collected by Hill.

In most industrial colour matching processes, the aim is to produce a sample having a spectral reflectance function as close as possible to that of the standard. If the reflectance functions are the same, the match will hold for all light sources and for all observers. This type of match is known as a spectral match. In many cases within the graphic arts industry it is not possible to obtain a spectral match using the desired set of dyes or pigments. If the reflectance functions are very different, then the match might be very good for one light source (e.g. D50 daylight) but may not hold for other sources (e.g. tungsten or TL84 fluorescent light). This type of match is known as a metameric match. The degree of metamerism may be quite small or very marked, depending on the difference between the two reflectance functions and the specific illuminant concerned. The degree of metamerism can be evaluated by calculating the colour difference under the second and third light sources (either visually or instrumentally).

Calculation of metamerism indices

In order to calculate the colour difference between two samples under different light source you need to know the spectral reflectance factor of both samples. Using these factors and appropriate software programs you can determine the colour difference under the reference (e.g. D50) and test (e.g. TL84) light source. If the two metameric object colours fail to be a precise match with respect to the standard colorimetric observer, a suitable account

should be taken of this failure. The nature of such account should be completely specified and the size of the failure recorded. In addition the used colour difference formulas such as ΔE^{*}_{ab} or CIEDE2000 should be indicated.
Figure 2.6 shows the reflectance factors of two different samples. The dotted red light represents a composed (CMY) grey of a proofing system while the blue line characterizes the a pure grey printed in offset lithography.

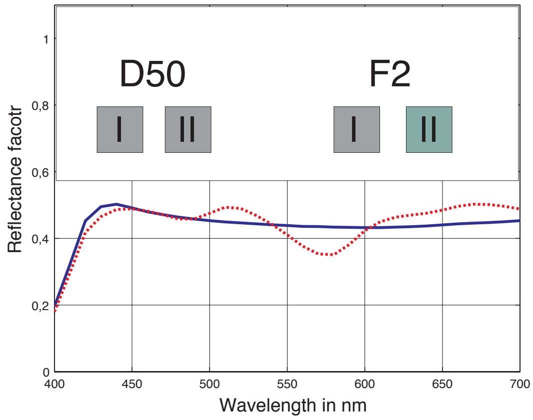


Fig. 2.6: Spectral reflectance factors of two metamers. They appear identical under D50 but show a significant colour difference under a typical office illumination, here „F2" (discharge lamp), --pure grey, - - - composed grey.

About metamers and paramers

The principle of metamerism, i.e. the lack of any colour difference under the reference illumination, is often not met in daily life (see also the example provided below). Such objects are called paramers instead of metamers.

Colour constancy

Colour constancy is a property of one sample that is often confused with metamerism. It relates to the property of an object to maintain the same colour appearance under a wide range of illuminants. One example: Using the two samples from Figure 2.6 it might be known that observing the composed grey sample will lead to different colour casts when seen under different illuminants. The pure grey sample however will mostly result in an chromatic appearance. Both phenomena are illustrated in Figure 2.7.

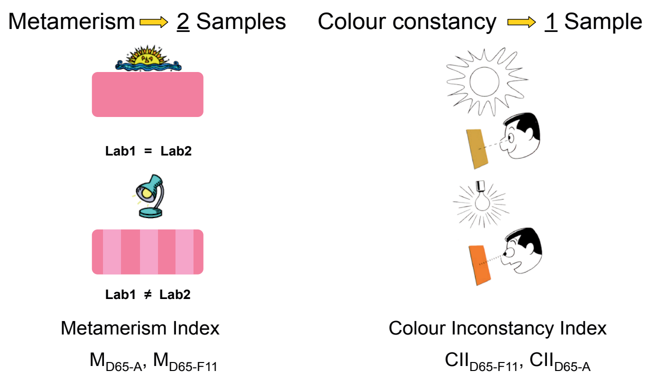


Fig. 2.7: Schematic comparison of metamerism vs poor colour consistancy (colour inconsistancy).

Example calculation: Metamerism Index change in illuminant

By using the Ugra metamerism indicator a concrete example on how to calculate a metamerism index should be given. It is made up out of three identical pairs of metameric samples lined up as depicted in Fig. 2.8. The samples are created in a way that they match under daylight (D50) and mismatch under different light sources. In this example a typical office illumination called TL84 (also termed CIE F11) is used as a test light source. Inspecting the Table 2.1 one can see that the indicator is using paramers instead of metamers since the colour difference under the reference light source (D50) is not zero ($\Delta E \neq 0$). It is CIEDE2000=2.9 instead, which can be attributed as a small but visible colour difference.

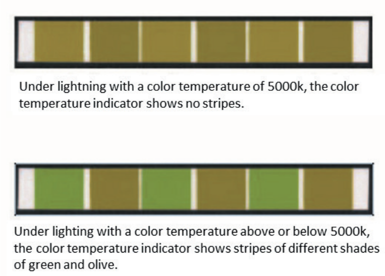


Fig. 2.8: Simulation of the Ugra metamerism indicator. Top: almost no colour difference under the reference light source (D50). Bottom: Significant colour different under test light source, here TL84.

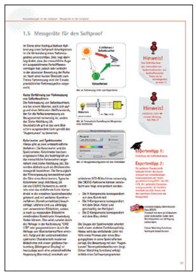
	Referene light source (D50)			**Test light source (F11)**		
XYZ - Ref	21.32	23.25	4.5	22.43	25.01	4.22
LAB- Ref	55	-5	47	57	-8	52
ΔE00	2.9 (small visible mismatch for D50)					
XYZ -Test	22.18	23.30	3.11	22.80	27.04	3.38
LAB - Test	55	-6	-50	59	-19	54
ΔE00	8.4 (significant colour difference)					
Details	CIE 1931 2° observer, Reference: D50, Multiplicative correction, since CIEXYZ values don't match under D50 -> paramers.					
$CIEXYZ_{Korr}$	-	-	-	21.67	25.14	3.6
LAB - Test	55	-6	-50	57	-16	50
$MI_{D50\text{->}F11}$	M_{ILM}=6.7					

Tab. 2.3: Calculation example to determine the metamerism index (change in illuminant). A very first guess can be made by simply subtracting the colour difference under the reference from those under the test light source. The correct method however needs to leverage (Null) the difference under the reference illuminant before calculating the colour difference under the test. Here the multiplicative correction has been applied.

2.3 Colour measurement

2.3.1 Colour communication needs colour measurement

When measuring colours it is advisable to separate between the measurement of surface and self luminous colours. The following guidelines focus on the measurement of surfaces while the reader might consult the free of charge Fogra Softproof handbook that focus on the measurements of self luminous colours, i.e. displays, both in contact and via distance measurements.



For more background information please refer to the Fogra Softproof Manual

Measuring surface colour

In order to communicate colour it is extremely important to agree on the intended usage of the measurement values. The main task of colour measurement is to mimic the colour sensation for a given set of viewing conditions. Though measurement devices are build in a way to "measure as we see". Important parameters of the viewing conditions are the illumination and detection geometries, the excitation of potential optical brightener agents (OBA) by means of a certain UV energy, polarisation and for not opaque samples the used backing material. Given that there are two substantially different use cases aiming for different goals:

- Measuring the final colour appearance, i.e. a high correlation to what a normal sighted observer perceives under a given viewing condition ("Measure as you see"). Here a 45°:0° (or 0°:45°) geometry is the best compromise for typical viewing and therefore standardized, e.g. in ISO 13655. The best way to reflect this is to use a tele-measuring device that is placed at the viewer positions by using a receiving aperture that is similar to the human visual system (typical 2°). Those devices are often tricky to handle. For that reason the most 45°:0° devices measure in direct contact. Here it is important to illuminate the sample as uniform as possible to avoid differences when slightly replacing the device. Also the focus point needs to be taken into consideration. In particular when using a scanning device that is not in direct contact with the sample.
- Measuring material properties by reducing any kind of surface induced effects. Here the measurement devices use an integrating sphere and a larger aperture. This allows for a diffuse illumination which in results in material independent readings. This kind of devices is typically used when there is a physical sample as the original.

For the given reasons it is extremely important to communicate the intended use case to allow for a meaningful interpretation of the measurement values. Different industries have established appropriate standards. The paper industry, for instance, uses ISO 5631 that defines an integrating sphere to assure consistent paper production across different sites while the graphic arts industry defines an 45°:0° directional illumination defined in ISO 13655 to allow for a colour appearance match between prints and monitors. However even within the printing industry a series of measurement illumination conditions M0, M1, M2 and M3 have been defined to address the different needs.

ISO 13655	light source	UV-content	Polarisation filter	UV-Cut filter	Reference	Backing
M0	incandescent lamp	low (but technically not defined)	No	No	D50/2°	wb/bb
M1	D50	as D50	No	No	D50/2°	wb/bb
M2	continuous	No	No	Yes	D50/2°	wb/bb
M3	continuous	No	Yes	Yes	D50/2°	wb/bb

Tab. 2.4: Overview of ISO 13655 M series of measurement conditions. wb/bb: white/black backing.

M1 – The measurement mode for Now and Tomorrow

Many modern printing substrates contain Optical Brightener Agents (OBA). These agents are added to enhance the brightness and whiteness (but not the CIEL* lightness) of the paper and improve the appearance of the printed product. They operate through the process of fluorescence by absorbing invisible ultraviolet (UV) radiation at wavelengths below 400 nm and emit light mostly in the blue end of the visible spectrum at about 430 nm. The perceived colour of a substrate that contains OBA will look different, depending whether the light source used to view the prints contain more or less UV. In practice, colours viewed under real viewing conditions containing UV sometimes were notably mismatched, and failed to meet expectations.

In order to find out the amount of OBA the CIEb* value provides a good indication. A negative b*-value mostly indicate a substrate that contains some OBA since the light emitted at 430 nm increases the blue reflection and hence the CIEb* value. However there are also papers with a negative b*-value that contain no OBA at all. This is cause by special dyes that are used to compensate the yellowish appearance of the row material. Therefore it is advised to check a substrate by means of both the coloration and the OBA-content. Two measurements can be used to achieve this; either a M0 and a M2 measurement or a M1 and a M2 measurement. For substrates with no or a small amount of OBA the UV-content of the measurement illumination can be neglected. That was the practice for older graphic arts measurement standards and lead to the confusion as to which measurement condition to use M0 or M1. With respect to the reference printing condition of choice, this selection can be translated into FOGRA39 (M0) and FOGRA51 (M1). Before ISO 13655:2009, and its recent revision ISO 13655:2017, it was assumed that all substrates would measure the same using a D50 illuminant, and OBA content was not a concern. Therefore all Fogra characterization data sets refer to D50 in the header information. The measurements however relate to the instruments that were available at these times which have been additionally altered to match the prints under the standard illumination at these times.

In order to minimize the measurement variability and to provide a way to communicate the illumination source used for measurement (and viewing), a new notation of measurement conditions was needed. As of FOGRA51, all further Fogra standards will be based on M1.

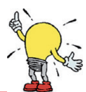
Mode M1 specifies that the spectral power distribution of the light source used to measure the specimen should match CIE illuminant D50. M1 also defines a "second part" that is only valid for measuring optically brightened papers but not for measuring inks or toners that fluoresce (often called "neon colours"). This second definition requires that a compensation method is used with a controlled adjustment of the amount of UV-component. This is to provide a high correlation to the D50 illumination conditions as stipulated in ISO 3664:2009/2017. The second method is mostly used when one UV-LED lamp is used.

Using a UV-filter is often referred to as a the problem solver. That is not the case since papers that differentiate themselves by means of their different OBA amount would virtually look (and measured) the same when the OBA won't be excited.

Since M1 compatible measurements are more and more available in this field, it is highly recommended to prefer M1 over M0 for all use cases. When using FOGRA39 as the reference printing condition, there are several challenges: The measurement of the reproduction must also be done with M0. However, a visual match then does require a viewing cabinet with the UV energy of illuminant A (M0) and not that of D50 (M1). So, working with M0 and M1 in parallel requires two viewing cabinets or one where the UV amount can be tuned. As this is an error-prone workflow, it is highly recommended to switch to a workflow with M1-based reference conditions, ISO 3664:2009


The M Factor...What Does it Mean?

More information about M0, M1, M2 and M3 can be found at the X-Rite white paper "The M Factor" or "ISO 13655:2009 demystified by Konica Minolta (https://www.konicaminolta.eu/en/measuring-instruments/learning-centre/colour-measurement/colour/iso13655-demystified.html).



OUR ADVICE

Switch over to M1-based workflows in order to avoid cumbersome workarounds!

viewing cabinets and the M1 measurement mode. For more information on this see "3.6 Migrating from FOGRA39 to FOGRA51".

ISO 13655	Typical applications
M0	For matching legacy data sets such as FOGRA39.
M1	Standard
M2	For use when paper fluoresces, but there is a desire to eliminate this effect from affecting the data (process control, closed loop calibration, or profiling where no ISO compliant print conformance is needed)
M3	For special use cases where first surface reflections should be minimized including the use of polarisation to do so. (In particular for process control in offset printing to reduce the ink setting effect)

Tab. 2.5: Applications and use of M0, M1, M2, and M3.

TIP

M1 measurements can also be used to easily determine the content of optical brighteners (OBA) of the used substrate!

By definition, the printing conditions FOGRA51 and FOGRA52 are defined for prints on papers containing OBA ("optical brightener agents"). The amount of optical brighteners in the substrate can be determined by measuring the D65-Brightness according to ISO 2470-2 and calculating the amount of optical brighteners (ΔB) according to ISO 15397 as the difference between a measurement with UV-excitation corresponding to a D65 measurement, and a measurement without UV-excitation (UV-Cut).
However, since not every (commonly used) handheld measurement device is able to determine this value, the following "workaround" can be used as well: OBA has not only the effect of brightening the substrate, but also of making it "more blue", therefore the difference of two CIEb* measurements – one with, and one without UV excitation – correlates well with the amount of optical brighteners in the paper.

TIP

Classification of the content of OBA:

$0 \leq \Delta B \leq 1$ = Free
$1 < \Delta B \leq 4$ = Faint
$4 < \Delta B \leq 8$ = Low
$8 < \Delta B \leq 14$ = Moderate
$\Delta B \geq 14$ = High

Blue shift: $\Delta CIEb^*_{M0,M2} = CIEb^*_{M0} - CIEb^*_{M2}$ or
$\Delta CIEb^*_{M1,M2} = CIEb^*_{M1} - CIEb^*_{M2}$

As a rule of thumb, you can simply halve and negate a ΔB value to get the corresponding ΔCIEb* value. The following table can be used to practically determine more precise results.

ΔB	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28
ΔCIEb*	-0.3	-1.2	-2.0	-2.9	-3.7	-4.5	-5.4	-6.2	-7.1	-7.9	-8.7	-9.6	-10.4	-11.3	-12.1

Tab. 2.6: Correlation between ΔB and ΔCIEb for everyday use.*

Don't compare apple with oranges

If you are trying to hit standardized values, "print to the numbers", or to meet customer supplied values, it is essential to understand the source of the values. Density values and hence tone values are less effected by illumination conditions but differ by means of the used status (E or T).

For process control there is no strict requirement of the used illumination condition since the primary aim is to keep process constant. That's why the mode M2 is mostly used here. Contrary, when profiling a digital press in order to match a legacy characterization data set such as FOGRA39, it is recommended to use the measurement condition that is used by the reference. With the advent of FOGRA51 and FOGRA52 now a proof to print match is achieved without any "gurus" and "compensations". In order to match an M1-based reference printing condition (FOGRA51, FOGRA52, FOGRA53 or FOGRA54), the machine profile also needs to be created in M1.

2.3.2 Colour difference evaluation

From colour to colour difference

Characterizing and evaluating colours differences can be done in various ways. Basically such a colour difference is understood as a (weighted) distance between two colours [typically two points in a coordinate system] in a reasonable colour space. While in some industries such as the textile or automotive industry there is often a physical reference sample and a reproduction or test sample in the graphic arts industry both colours are normally equally important and no specimen takes precedence over the other. That is important since colour difference equations such as the CMC formula might not always be symmetric, i. e. ΔE_{CMC} Ref. vs. Test ≠ ΔE_{CMC} Test vs. Ref.
The most common colour space to define colours is the 1976 CIELAB colour space, which can be visualized by both cartesian as well as polar coordinates, see Fig. 2.9 for an example.

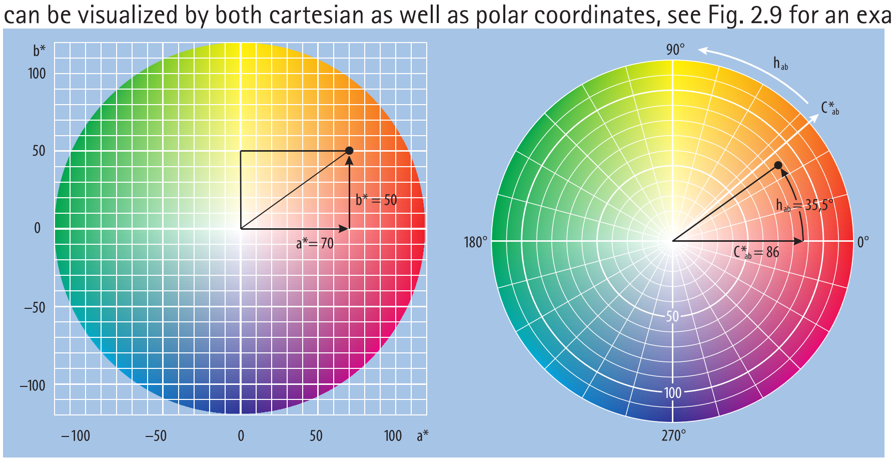


Fig. 2.9: Portraying two different ways to specify one colour. Left: the usage of CIEa and CIEb* in the so called cartesian coordinate. Right: Using the hue angle CIE_{hab} and CIEC* (the distance from the achromatic axis) to describe the exact colour. Note: It is only the CIEa*b*-plane, so the lightness information is retained. Source: bvdm.*

As colour is three-dimensional there are three coordinates (figures) needed for an unambiguous definition. This is usually facilitated by a lightness component (e. g. CIEL*), a hue angle (e. g. CIE_{hab}) and a chroma component (e. g. CIEC*). Since Figure 1 is only showing two of the three dimensions one must be cautious when interpreting colours or colour differences to not forget the "missing dimension". In this example it is the (neglecting of the) lightness information, which will be important for this report. So a three dimensional visualization is strongly recommended to get the full image. If, as it is normally the case, the CIELAB values are given, the CIEC* and CIE_{hab} are calculated as follows:

CIE Chroma: $C^*_{ab} = \sqrt{(a^*)^2 + (b^*)^2}$

CIE hue angle: $h_{ab} = \arctan(b^*/a^*)$.

What is a colour difference at all?

Having now two colours, e. g. an aim CIELAB value that is to be printed and a measured value of a digital print, one common way of computing a colour difference is to calculate the length between both points (in the defined colour space). This is done by calculating the difference for the three dimensions, typically the lightness-, hue angle- and chroma-differences or the lightness, "redness-greenness" (CIEa*) and "yellowness-blueness" (CIEb*) differences. Based on the well known Pythagorean theorem ("$a^2+b^2=c^2$") the resulting distance (ΔE) is calculated as follows:

This is illustrated in Fig. 2.10 and shown by means of a concrete example in Table 2.4.

$$\Delta E^*_{ab} = \sqrt{\left(\Delta L^*\right)^2 + \left(\Delta a^*\right)^2 + \left(\Delta b^*\right)^2}$$

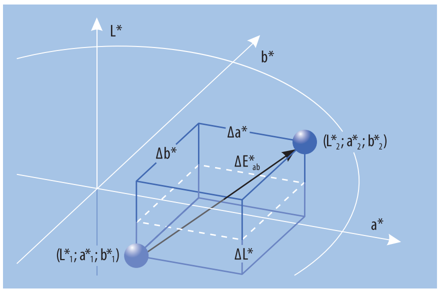


Fig. 2.10: Visualization of the colour difference components, here the lightness difference ΔL, the "redness-greenness" difference Δa* and the "yellowness-blueness" Δb*.*

	CIEL*	CIEa*	CIEb*	CIEhab	CIEC*
Reference	55	-37	- 50	= arctan(-50/-37) = 233,5°	= square root (-37^2+-50^2) = 62,2
Print	53	-35	- 48	= 234°	= 59,4
Difference	ΔL=55-53 ΔL=2	Δa=-37-(-35) Δa= -2	Δb=-50-(-48) Δb= -2	= 233.5° - 234° = Δh=0.5°	= 62.2 - 59.5 = ΔC*=2.7

Tab. 2.7: Example calculation of two colours by means of the characteristic differences. The reference represents the Cyan solid for FOGRA39.

That results in a total colour difference (ΔE^*_{ab}) of:

$$\Delta E^*_{ab} = \sqrt{2^2 + (-2)^2 + (-2)^2} \qquad \Delta E^*_{ab} = \sqrt{12} = 3{,}45 \approx 3{,}5$$

The computation of modern colour difference metrics such as CIEDE94 or CIEDE2000 is more complex and is explained elsewhere. For information both have been calculated for this example to CIEDE2000 ≈ 2 and CIEDE94 ≈ 2.1. The "E" stands for the German word "Empfindung", which means "perception". The unit of ΔE^*_{ab} is 1, so you normally would write: "The colour difference of my brand colour was ΔE^*_{ab} = 2.3 today" and not "The colour difference of my brand colour was 2.3 ΔE's". Conceptually (psychophysically) ΔE=1 represents one just noticeable difference.

Hint:

The weighting factors for CIEDE2000 k_L, k_C and k_h should be set to 1.

Why is a total colour difference not enough?

As you can spot in Table 1 one can infer more information than only the total colour difference ΔE. Colour difference information, such as the lightness difference, the hue angle or the chroma difference, might give additional explanation in how to solve daily colour management challenges: "Do I need more density to achieve the aim?" or "Is the hue angle achievable at all?". Having a closer look at the formulae defined in Table 1 one must be cautious in using the right terminology. So the chroma difference ($CIEC^*_1 - CIEC^*_2$) between two colours is termed ΔC*. This if often confused with the colour difference in the CIEa*b*-plane, which this article is all about.

In defining a reasonable hue-angle ("colour cast") difference, e.g. from a blue to purple blue, the statement of Δh in degrees is not appropriate. Imagine a pale colour (CIELAB3 in Fig. 3) and a saturated colour ($CIELAB_2$ in Fig. 2.11) would have the same hue angle difference. For that reason a more appropriate hue angle difference metric has been defined, namely the CIE hue contribution: ΔH. It is calculated as follows:

$$\Delta H^*_{ab} = \sqrt{\left(\Delta E^*_{ab}\right)^2 - \left(\Delta L^*\right)^2 - \left(\Delta C^*_{ab}\right)^2}$$

You can imagine this result as what is being left of the colour difference if the lightness and the chroma differences have been "removed". Technically or geometrically speaking, it is the cord between the "hue rays" of both colours on the geometrical mean. The sign indicates whether the colour change is to the "redish side" (clockwise) or to the "blueish side" (counter clockwise). If you use the formulae above, all ΔH values are positive. This reduces problems that would occur if you evaluate several ΔH values in order to calculate an average or mean value, as it is required for the composed grey patches of the control wedge defined in ISO 12647-7.

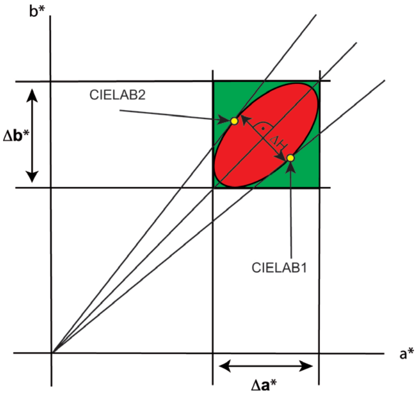


Fig. 2.11: Visualization of the hue rays of two colours and the corresponding areas for a Δa, Δb* colour difference definition (green) and a CIELCh based definition.*

ΔCh – the most reasonable way to characterize near neutral colour differences!

So far we have seen colour differences somewhere in the colour space. Close to the grey axis, in other words for near neutral colours (typically with a ΔC*<7), the usage of an explicit hue is not appropriate. The closer a colour lies to the neutral axis the less meaningful a hue becomes. In Figure 2.11, for example, there is no hue difference for a grey colour with CIELAB_A=50,0,0 and CIELAB_B=50,0,-3. Anyhow, one will perceive colour "A" (compared to colour "B") as yellowish. In order to solve this, you simply compute the distance of both colours in the CIEa*b*-plane (neglecting the CIEL* information) as follows:

$$\Delta C_h = \sqrt{(CIEa_1 - CIEa_2)^2 + (CIEb_1 - CIEb_2)^2} = \sqrt{(0.5-(-0.5))^2 + (0-0)^2} = 1$$

This difference is called chromaticness and is defined, among others, in DIN 55981, ISO 12646 (called ΔE_C) and now in ISO 12647-8.
All three near neutral pairs have, from a relative point of view, the same chromatic difference. From an absolute point of view, the pair "A2-B2" appears more blueish and "A3-B3" more greenish. This "absolute perception" will only occur if the "neutral" patch "A1" is present in the field of view. Without this "orientation" all "B-samples" have a "yellow-reddish" cast compared to the "A-samples". Conversely all "A-samples" comprise a bluish-green colour cast compared against the "B-samples" – including the neutral patch A1 compared to B1.

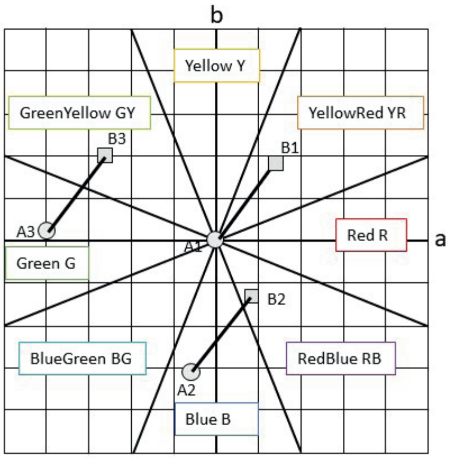


Fig. 2.12: Three near neutral grey pairs where „B" has always the same colour shift as „A". T

In Conclusion:

For the given reasons the assessment of gray balance will be conducted by using ΔCh for all relevance standards (proofing as defined in ISO 12647-7, design proof as defined in 12647-8 and PSD as defined in ISO/TS 15311-2).

2.4 How ICC works

The basic concept of ICC colour management is the separation of colour transformation between image capturing and image reproduction. This de-coupling has been achieved by introducing a PCS, a profile connection space, namely CIELAB. A typical ICC colour conversion contains an input profile, that covers the transformation from the device dependent coordinates of the scanner or camera into CIELAB (or CIEXYZ), and an output profile that contains the rendering from the CIELAB colour space to the device coordinates (and the associated device gamut). That concept is visualized in Figure 2.12.

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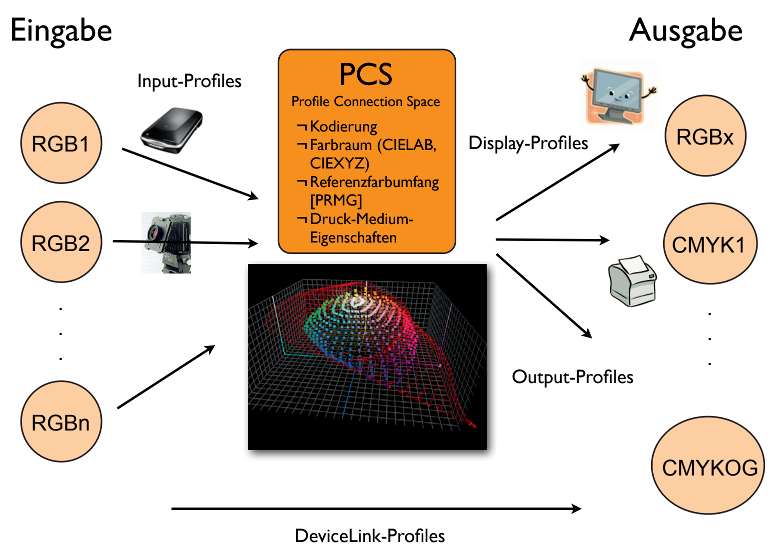


Fig. 2.13: Schematic overview of the ICC colour management paradigm.

A sample will be digitized by means of a scanner or a digital camera. The ICC-source profile converts from e.g. sRGB values to the CIELAB colour space. In order to map these colours to a given printer, a colour matching module (CMM), which connects the transformations mathematically and performs the final transformation is needed, e.g. into the CMYK device coordinates. In the same manner a direct transformation from RGB to CMYK, without going to CIELAB, is possible. This is called a "Device Link profile". The red colours displayed in Figure 2.12 represent all possible reflective colours, termed "optimal colours". The gamut depicted in "real" colours represents the perceptual reference media gamut (PRMG) which provides guidelines for ICC-profile builders to increase interoperability.
Reproducing colours by means of ICC refers to a metameric reproduction. This means a colour is defined by three coordinates describing its appearance for the CIE 2° standard observer and D50 illuminant. D50 was chosen in 1993, when ICC was established alongside a Fogra symposium, since ICC was created in the realm of printing. Today, ICC also addresses the motion picture industry and others.
However reproducing colours across different devices with different (gamut) limitations different there are many ways to render colours. Four important rendering intents have been defined by the ICC, see Tab. 2.5.

Transformation: Device → PCS	Transformation: PCS → Device	Description
AtoB0	BtoA0	Perceptual Reproduction
AtoB1	BtoA1	Media-Relative Colorimetric
AtoB2	BtoA2	Saturation
AtoB3	BtoA3	Absolute Colorimetric

Tab. 2.8: Overview of the four rendering intents defined by ICC. The transformation covers both "directions". On the one hand the forward direction from device coordinates to PCS and the inversion direction when going from CIELAB to the device.

Two colorimetric rendering intents are specified by ICC (ISO 15076), though only one is included as fully constructed in the profile. The included media relative colorimetric intent is based on media-relative colorimetry, which is normalized relatively to the unprinted media white for reflecting, transmitting, and self luminous media, or, in the case of colour encodings and capture, to the colour encoding values that correspond to the highest perceived brightness. Thus the media white will have the values of 100, 0, 0 in PCSLAB. This ensures that highlight clipping will not occur when the media-relative colorimetric intent is used. The use of media-relative colorimetry enables colour reproductions to be defined which maintain highlight detail, while keeping the medium 'white', even when the original and reproduction media differ in colour. However, this rendering intent introduces some change in all colours in the reproduction when the media whites of the source and destination do not match. The calculation of the media neutral $CIEXYZ_{mr}$ values is as follows:

$$X_{mr} = (X_{D50}/X_n) \times X_{absolute}$$

Here X_n, Y_n, Z_n represent the tristimulus values of the substrate, X_{D50} the colour values of D50 (X_{D50}=0,9642) and $X_{absolute}$ represents the "normal" measurement values. CIEY and CIEZ will be calculated analogously. The media relative values are stored in the profile by means of the AtoB1 and BtoA1 table. In order to apply the absolute colorimetric transformation, the content of the media relative table will be used together with the (paper) white point to determine the absolute values. The media relative colour encoding is very efficient. In addition it allows for a colour reproduction that is applicable when colours are observed in isolation (instead of a "Side-by-Side" proofing workflow, where you need a match of the absolute values). The assumption is made that the observer is fully adapted to the individual situation. The media relative way of encoding colours will therefore be used for conformance assessment when the use cases require a media relative assessment and reproduction. The exact colour rendering of the saturation intent is vendor specific and involves compromises such as trading off preservation of hue in order to preserve the vividness of pure colours.

Because perceptual rendering generally involves mapping the colours of a source to be well-suited for a destination medium (i.e. colour rendering and/or colour re-rendering), it is desirable that the perceptual intent PCS reference medium (PRM) and associated viewing conditions are well-defined. Then the source profile can perceptually render from the source to the PRM, and the destination profile can perceptually render from the PRM to the destination medium. The PRM in the PCS serves as the common intermediate representation. Well-defined viewing conditions are required because they will affect the appearance of colour content represented on the PRM. Perceptual rendering remains a proprietary art, due both to the current state of perceptual rendering algorithms, and also to the fact that viewer and application specific preferences can affect the nature of a desired reproduction (when exact colour matching is not the objective). It is not practical or desirable to specify standard perceptual rendering algorithms. Consequently, it is also not practical or desirable to require perceptual rendering intents to match an exact perceptual intent reference medium gamut (PRMG). Gamut mapping could be applied to clip the results of a perceptual rendering algorithm to a specific target gamut, but that would result in a loss of information and reversibility. Therefore, the reference medium white point, black point, and viewing condition attributes of the PRM are defined precisely, and the PRM gamut is defined to be a fuzzy target that can be used as the aim of perceptual rendering transforms, but does not have to be exactly matched.

If the illumination on the test object or reproduction medium (e.g. store light) differs from the reference illuminant (D50), it will be necessary to apply a chromatic adaptation transform (CAT) to the measured values. For the media-relative colorimetric intent, scaling to the media white point is then performed to produce values appropriate for the PCS. The CAT-Tag covers this information. For the perceptual intent, other factors such as the viewing conditions, differences in gamut between the actual and reference media, and user preferences also need to be considered by the profile builder.

ICC defines seven different types of profiles that are used for different purposes. They differ by their required tags and other content. The four most important types are:

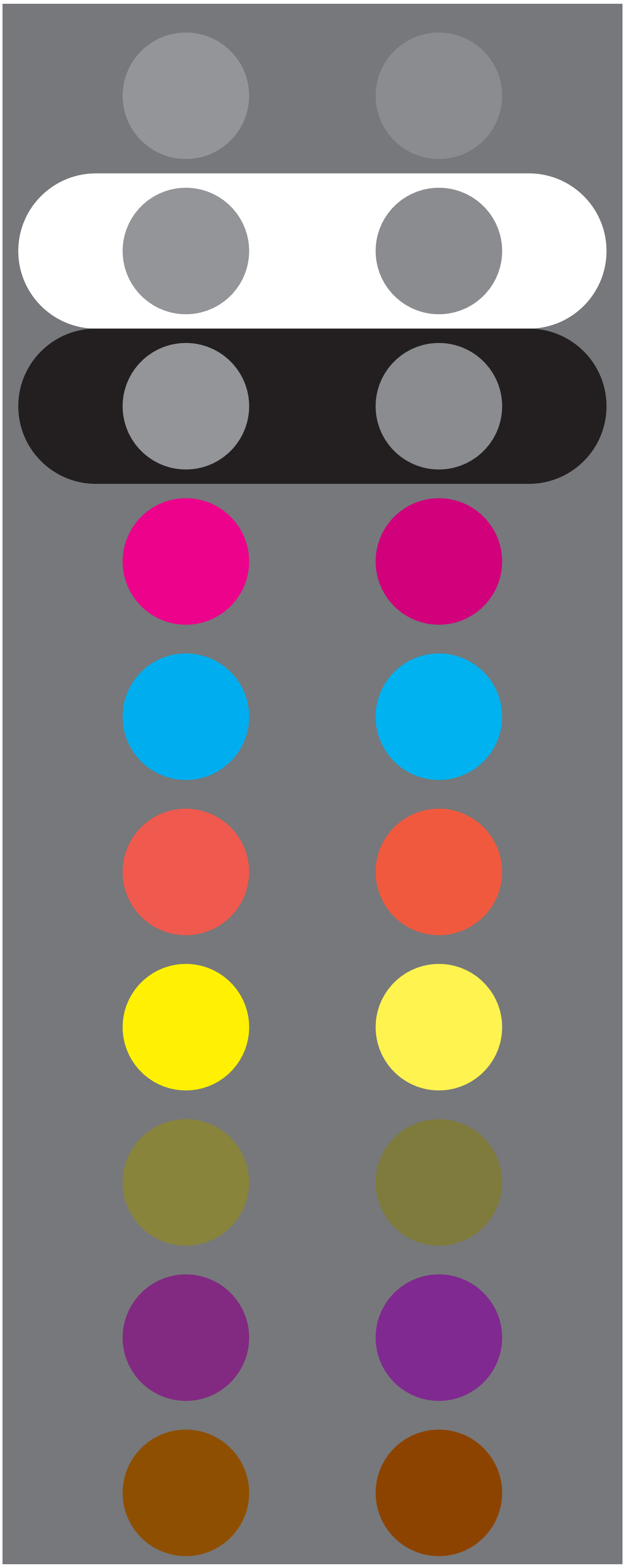
- Input Profiles, are generally used with devices such as scanners and digital cameras. The types of profiles available for use as input profiles are N-component LUT-based, Three-component matrix-based and Monochrome.
- Output Profiles, are used to support devices such as printers and film recorders. The types of profiles available for use as output profiles are N-component LUT-based and Monochrome. A typical example is PSOCoated V3 (ECI) that covers the transformation from CMYK to Lab (and the inverse being the separation table).
- Display profiles, represents display devices such as monitors. The types of profiles available for use as display profiles are N-component LUT-based, Three-component matrix-based, and Monochrome
- DeviceLink profiles, provide a dedicated transformation from one device encoding to another, which can be useful in situations where such a transformation is used frequently or has required optimization to achieve specific objectives.

The biggest difference between DeviceLink profiles and other profiles is that a DeviceLink profiles only contain one rendering intent, therefore they make no use of the original concept of the flexible mapping of input and output transformations. Instead, they are optimized for one dedicated transformation important to the digital print service provider. They often have to print data prepared for offset printing (e.g. FOGRA51) and need to apply a transformation that finds a compromise between a good colorimetrical match and other print related issues such, as pure primaries or an ink saving option. It should also be noted that ICC (or non ICC conforming) DeviceLink profiles are not invertible.

Finally it should be mentioned that ICC-based transformations are static, i.e. precomputed for a given process and then applied on a pixel by pixel basis (irrespective of the neighbourhood).

Modern ways of colour transformation take the local neighbourhood, as well as the source and destination gamuts into consideration. These approaches are an active field of research. However, there are proprietary products in the market, particularly in the field of image enhancement.

TIP: Cut this side off and check it yourself how good ΔE^*_{ab} and CIEDE2000 correlate with your perception.



Your Visual Colour Difference	ΔE_{76}	CIEDE2000

2.5 Basics of print data separation

2.5.1 Introduction

The terms „UCR“ [Under Colour Removal] and „GCR“ [Grey Component Replacement] are used quite frequently - but often not consistently.

Commercial offset printing mostly uses the primary colours Cyan, Magenta, Yellow and Black. This “CMYK-scale” requires that all elements, graphics and rasters must be prepared by means of an appropriate CMYK tone value combination. Here, spot colours can be thought of as additional colours that are often used as solids for brand colours. Cases where additional colours are used as primaries in the same way as CMYK (e. g. Hexachrome) are not considered here.

Separation and print data preparation

The determination of the CMYK tone value combinations (also known as tone values or ink combinations) are normally entitled “separation”. Preparing CMYK data from already separated CMYK is termed “re-separation”. The separation process only addresses the suited CMYK combination representing a colour within the gamut. Gamut mapping, i. e. the substitution of an original unmatchable colour with a different reproduction to achieve visual similarity, is not part of the separation and needs to be done before. Gamut mapping is still highly subjective, since preference and pleasantness are hard to define objectively.
That means, the gamut of the output device has to be known in order to do the separation. This also applies for output processes with more than four primaries such as CMYKRGB or CMYKCc,Mm,Kk. However the number of ink combinations drastically increases with the number of used primaries.
The appropriateness of a separation for a given printing process is governed by two major parameters, namely the used screening and the colorimetrical and print related properties of the used primaries. Such properties are the typical level of misregistration, the tone value reproduction limit, the minimum thickness of lines that can be imaged and printed in a reliable fashion, the screening frequency and hence the risk for visible structures such as pepper corn or the tone value sum (TVS). The tone value sum is often known as the total ink coverage (TIC) or the total area coverage (TAC). The combination and interplay of these governing factors is termed “channel specificity”. This characteristic behaviour is responsible for a separation that mostly follows a set of rules to use the suitable CMYK tone value out of a number of combinations that all correspond to the same CIELAB colour (instead of using a random CMYK-combination, what is theoretical doable). Depending on the pertinent aims, a cost function can be determined that reflects the practical rules to be followed. These rules, as well as the special role of the black printer, will be explained in the following paragraphs.

Typical aims for separation algorithms

- **Save costs:** by replacing primaries among each other or replacing (expensive) chromatic primaries with black by keeping the same level of colour accuracy. For office printers this is often adapted for an optimal use of the ink cartridges. In the graphic arts you can mostly find "ink saving" transformation that perform a GCR in order to replace pure with chromatic inks.
- **Reducing post press issues:** Reducing the maximum tone value sum by replacing chromatic inks with the black ink without significantly compromising colour accuracy. It should be noted that reducing the TVS might lead to a reduced gamut in the dark chromatic colours, which is not primarily caused by the physical restrictions, but by sub-optimal separation algorithms.
- **Stabilizing the printing process:** Print process dependent replacement of chromatic inks by ink combinations with dominant use of black ink for neutral and near neutral colours.
- **Improve print quality**: Facilitating CMYK combinations that reduce visible artefacts such as "pepper corn" (e.g. by using black for skin colours).
- **Maximizing colour constancy:** Facilitating CMYK combinations that maximize colour constancy. That refers to stable colour appearance under a wide range of illuminations.

The importance of the black printer ["Black Generation"]

As described, the black channel or black printer play a dominant role for CMYK-based separations. When describing separations it is important to know that the black content or black portion is a relative unit, i.e. to be expressed as a percentage. This percentage is calculated from the number of CMYK combinations that all correspond to the given colour. For example a mid grey, CIELAB=50,0,0 [D50/2°/wb], can be reproduced with more than 500 different CMYK combination that all correspond to that colour within a $\Delta E^{*}_{ab} \leq 1$. The number of potential CMYK combinations decreases with increasing lightness or chroma since there are simply less CMYK combinations possible to result in that very colour. Black generation therefore can be understand as the colour specific selection of the black proportion. Two extreme ways of black generations are visualized for a neutral colours ranging from black (CIELAB=20,0,0) to white (CIELAB=90,0,0).

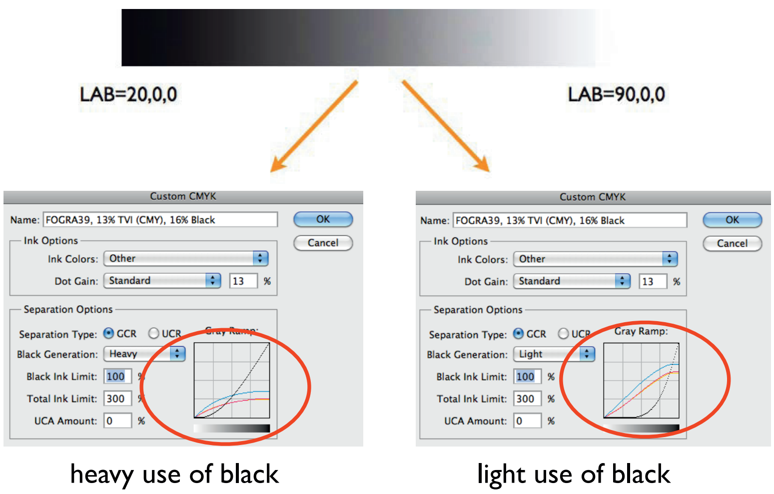


Fig. 2.14: Visualization of two different black separation strategies by using Photoshop CS 6. Left: strong usage of black ("heavy GCR"). Right: Weak usage of black or strong usage of chromatic inks ("Light GCR").

Both dialogue boxes show the resulting CMYK combinations based on a separation of a gradient from black to white. The screenshot on the right side shows an example where neutral colours are mostly printed by using chromatic inks - Cyan, Magenta and Yellow (CMY). Only for very dark colours, where the overprint of CMY is not able to achieve the required darkness, the black channel will be used. This is referred to as "minimum GCR" (Grey Component Replacement). Contrary, the left side shows a "strong GCR" and the utilization of the black printer as much as possible.
The parameters on the left side of the box provide the use a fine adjustment of the black generation. These parameters affect not only the neutral colours but also the chromatic ones, which is typical for GCR.
Another phrase which is often used in black separation is "under colour". Given a CMYK separation, this refers to the lowest portion among the chromatic inks. In other words, but colorimetrically not perfectly correct, it is that amount that does not contribute to the chroma portion of a colour. As an example the CMYK combination 55/45/40/0 should be used (here reflecting FOGRA39). The under colour would be 40% which relates to the assumption that 15/5/0/40 would be the same as 55/45/40/0. The exact calculation results in CMYK=54/44/45/0 and CMYK=7/5/8/55 respectively to achieve a mid grey of CIELAB=55,0,0 (D50/2°/wb). A separation algorithm or strategy that results in such a CMYK combination is termed "Under colour removal". Using the same analogy the addition is termed "Under colour addition". Contrary to the GCR the UCA or UCR is restricted to near neutral colours. The parameter "black width" helps here since it allows to adjust the black portion to be used for chromatic colours ("starting" from the grey axis).
A consistent and straight forward understanding of the black separation terminology is hindered by the legacy usage coming from the analogue photographic process using opponent colour filters. The before mentioned UCR resembles a re-separation, since the under colour can only be computed by an existing CMYK-combination. Using digital technologies that must be attributed as wrong since today algorithms calculate for all colours the number of potential CMYK-combinations and then apply the set of rules explained before. Technically a lightness based and a chroma based weighting function can be used as a basic approach. However it must be said that many software programs use the term inconsistently.
In conclusion it can be said that a separation for an offset print related can be fully characterized by the black generation and the maximum tone value sum.

The importance of the separation for pre-media purposes: „Info-Colour" versus „Image-Colour"

When preparing image content the data creator must recognize the "channel specificity" in order to create appropriate separation. Here two different intentions can be found. On the one hand there is the reproduction of graphics which are termed technical tones, i.e. pure colours where at least one chromatic ink is zero. On the other hand there is the colorimetrically accurate reproduction, which might lead to CMYK tone values that are not meeting the requirements of the technical tones. A typical example is a pure Yellow (CMYK=0,0,100,0) prepared for offset printing, that should be reproduced with a large format printer that can't exactly match the offset gamut. Printing the values "as is" the resulting print still looks like a bright yellow but a side by side comparison might fail to match. Simulating the "offset yellow" might require a CMYK=0,5,95,0, which might lead to visible artefacts (due to the magenta dots).
In order to sort out this trade-off it is important to resolved the final intention (or the rendering intent) of a graphical element before the separation. Practically the first case refers to graphics that are used to create a high contrast to communicate "information", which is termed here "Info-Colour". "Info-Colours" are always defined by means of device coordinates, mostly CMYK. The colour accurate reproduction is mostly required for pixel images (= raster), hence the term "Image-Colour".
Many problems and reclamations in the realm of printing can be traced back to errors and misunderstandings in the data transformation path the refer to the interpretation of the image content as "Info"- or "Image-Colour".

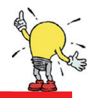
Any printing process needs its dedicated separation

Print shops often receive data of unknown origin and quality. In spite of the huge improvements in automation of preflighting and data correction often manual steps are needed to achieve imposed data across the print format that reflect the same black generation and total ink coverage. In particular that is important for offset printing since image content with conflicting black generation (within the print format) makes a consistent control of the press run almost impossible for the print operator. That is the also case when images are prepared for the same printing conditions but with different ICC-profiles, hence different gamut mapping and black generation algorithms. Imagine a grey separated in one image with CMY and in another with K only. The proof print would show the same result but within a print run a manual correction of the ink keys (e.g. optimizing a skin tone with a minus-correction in Magenta) might result in a hue shift of the composed grey (CMY) and no changes for the K-only image. For that reason the following paragraphs cover important properties of a separation including the explanation of how to deal with contrary goals.

The total ink coverage (maximal tone value sum): "Compromising shadow details or quick post press"

A maximum tone value sum (TVS) or total area coverage (TAC) is part of the separation strategy built in an ICC-profile. However that is only the case for image content that was created that way. Control elements or technical tones might be designed in CMYK directly and might exhibit a TVS of 400%. A typical example is the registration mark. That shows already that the simple presence of image content above a certain TVS-limit is not critical. It is the combination of the TVS with the pertinent size that might result in printing and post press processing problems. Typical problems are ink setting, blocking or the longer drying time. In sheetfed offset printing the maximum tone value sum is typically about 300% to 330% while for web-offset printing the TVS might be well below. Newspaper printing for instance might use a TVS of 220%. But it is not the plain reduction of the maximum tone value sum. The strength of the GCR also comes into play. Two important use cases will be mentioned to explain the details.

- **Maximum TVS for digital printing:** A limitation of the total ink limit is of great importance for both inkjet and electrophotographic printing. However these limitations are part of the calibration being part of the RIP or driver hence a limitation in the layout might not be needed. In other words a large font with 400% ink coverage might be printed without any problems since it will be appropriately reduced by the (typically channel wise (4x1D LUT) but more and more done by means of a multi-dimensional 3D-LUT) final transformation (within the RIP or driver) that result from the calibration.
- **Exclusive reduction of TVS:** Some news printers claim to reduce the ink limit to 180%. For typical "Info-Colour" objects, such as a pure red element, this means that this can't be printed as a solid (100% Magenta + 100% Yellow > 180 %). This problems "vanishes" when the transformation will be done on a object specific level and when it will be done appropriately, which means to set in within the gamut boundaries but not at the edges. A pure red therefore stays a pure red but the majority of the colours will be re-separated with tone value combinations below the chosen ink limitation (TVS). However, as soon as only one (DeviceLink) transformation is used for the entire document (for raster and graphics) a TVS-limit below 200% is not appropriate. That is the case for flattened PDFs, since here often pixel images (raster) result from this process. A different handling would result in colour differences at the intersections.



HINT

Since data will be prepared more and more for a general printing process (exchange space) and not for a dedicated digital printing process, such a TVS-rule is not part of the preflight profile anymore.

Schematic visualization of the separation process

The prescribed properties of the separation and the re-separation respectively are visualized in Figure 2.15. The starting point of the separation is the (gamut mapped) CIELAB colour coordinate. As said it is required that the colour to be separated must be within the gamut of the pertinent printing condition. Two governing factors contribute to the separation algorithm or strategy. On the one hand there is the channel specificity and on the other hand there are the use controlled aims. For CMYK based printing processes the result of a separation are the $CMYK_1$ tone values. In digital printing it is very common to re-separate the incoming (most for offset printing prepared) data to address both the rendering intent of the user and the aims and channel specificity of the final or actual printing process. This results in $CMYK_2$. The direct specification of CMYK tone values by the creative person or the designer can also be understood as a separation. A common example for re-separation is the image retouching of CMYK images to be printed for a new printing condition.

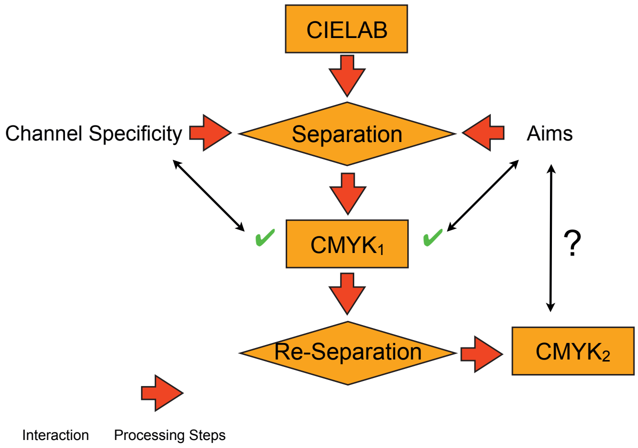


Fig. 2.15: Schematic sketch of a separation. The origin is the CIELAB colour that needs to be inside the printable gamut of the printing condition of interest.

Recommendation for the field

As outlined the publishing industry moves ahead toward a process independent preparation of image content. That transition from an early binding to a late binding results in image databases that are stored in profiled RGB (preferably ECI-RGB v2). That means they are media neutral, i.e. not separated for a given printing process. However due to the channel specificity of printing processes nowadays, such as offset printing and many digital printing processes, it is still required to prepare technical tones ("Info-Colours") in CMYK. In particular, black text or spot colours printed as an individual colorant ("CMYK+Spot") are good examples.

Retouching the pixel images in the RGB format should be accomplished by an activated softproof using a well established exchange space such as ISOCoated V2 (eci). That allows the colours to be checked for a potential rendering at a later stage. In addition the usage of RGB based raster data allows for the application of one separation strategy at the service provider instead of many different ones in case of the process specific way ("early binding"). For that reason it is advisable to not retouch the images in the CMYK mode anymore.

The usage of PDF/X compliant documents, where the separation will be done when creating the PDF ("Intermediate Binding"), in combination with a contract proof or a validation print facilitates the predictability of the designers creative intent.

2.5.2 Usage of DeviceLink (DVL) transformation

From conventional ICC-Colour management to DVL-transformations

Separating black text (e.g. defined as R=G=B=0 or K=100) by means of conventional ICC output profiles typically results in composed greys. Channel specificity of typical offset printing processes refers to a lack of perfect registration between the printing units. Fine structures such as text or lines that are composed of more than one colorant (channel) might end up showing colourful halos at the edges of the elements.
Using different separation strategies for gradients that are either defined as a graphical element by means of a smooth shade or as pixel image might lead to dazzling effects. Using different separation mechanisms also raises problems when two elements which are placed exactly next to each other - intended to match visually - are affected. The different separation will come into place when colour management settings differ between images and graphics, e.g. when graphics are interpreted as "Info-Colours" and images as "Image-Colours".
The main problem outlined here relates to the basic concept of the three dimensional PCS (profile connection space) that transforms all incoming colours to CIELAB or CIEXYZ and hence all separation specific information is lost. The following transformation from the PCS to the destination colour space cannot differentiate between a CIELAB=50,0,0 being a 50% black text or a CIELAB=50,0,0 of a pixel in a pictorial image. These examples show that additional types of transformation are needed which transform colours from CMYK to CMYK by recognizing the channel information. For these kind of tailored source to destination transformation the ICC has defined so called DeviceLink (DVL) profiles, see also chapter 2.4. It must be noted that the same result can be achieved with conventional source and destination profiles when a smart CMM (colour matching module) is used which computes the DeviceLink transformation on the fly. It is also important to note that a DVL-profile does not need to be compliant to the ICC specification. However in these cases proprietary colour servers are needed. Typical examples where the usage of DVL-profiles are useful are described in the following paragraphs:

1. Converting old image content:
Legacy image content is often stored as CMYK. They were often carefully prepared for a printing condition by means of meeting practical separation aims such as avoiding black tone values for skin colours. In order to maintain this channel specificity a DVL-transformation is needed. Using suitable DVL-profiles old image content can be automatically re-separated for up-to-date printing conditions including a harmonization of differently separated images.

2. Optimize gamut mapping:
Before ICC V.4 there was no information of a reference medium or gamut of the PCS. Hence profile creators for printer profiles must assume almost all kinds of colours to be nicely mapped into the defined printer gamut. With ICC V.4 there is the perceptual reference medium gamut (PRMG, see chapter 2.4) that helps to minimize ambiguity in this case. However, creating DVL-profiles for a defined set of source and destination profile allows for an optimized gamut mapping since the source colour gamut is known. Yet DVL-profiles providing a transformation from a typical image database colour space such as Adobe-RGB towards well established printing conditions such as FOGRA51 without the need of additional gamut mapping adjustments are available.

3. Optional separation adjustments (optimization)

Separating images for a general printing condition or an exchange space such as PSO Coated v3 (ECI) will be done without a strong grey component replacement (CGR) in order to leave "headroom" for potential re-separation and adjustments for the print operator. However, if the final printing condition is known and the data is not subject for further data exchange, a stronger GCR can be applied to save ink, stabilize the grey reproduction or reduce drying times.

However any re-separation (of the customer data), in particular when live transparency is involved, might lead to unwanted results and should therefore be checked by means of a contract proof or a validation print.

PRACTICE

Unless the colour accuracy with respect to the defined reference printing condition is not significantly compromised it is not typical in digital printing (contrary to offset printing) to negotiate with the customer.

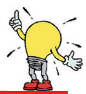
Using DeviceLink profiles requires the same assessment of its quality as for conventional profiles. Due to its great functionality, whereby it finally contains only one rendering intent, the testing criteria and tolerances greatly depend on the pertinent use cases as well as the involved source and destination colour spaces. The latter one is important in a twofold fashion. First, the final printing condition is often not known when creating the document. Second, the delivered RGB image content is not defined by means of tagged ICC-profiles. Here the print service provider must estimate the most likely source colour space and hence the DVL-profile to be used. In light of the different perspectives and use cases a generalized overview will be proposed that helps to identify the appropriate test criteria.

Separating prepress from press – still appropriate?

For conventional printing and in particular offset printing it was appropriate and useful to separate between prepress and press by means of responsibilities and typical requirements. The interface was clearly identifiable as films, i.e. halftones colour planes. Since there are no films in digital printing and the amount of film based workflows in the offset printing world is decreasing, the question is whether to maintain a separation between prepress and press.

It turned out that a separation is still useful and helps to understand different use cases with corresponding responsibilities and requirements. However the demarcation line now can be found by asking the question if the print data will be further used and repurposed or not. The background was already described before namely the different separation characteristic for image data that is subject for multiple output conversions and print data that is prepared for a defined printing process and subject for subsequent deletion.

In the first case the head room for both gamut size and GCR-amount should be as high as possible. With respect to the printing condition (PC), the well established printing condition FOGRA51, i.e. offset printing according to ISO 12647-2:2013 on premium coated stock, is taking the role as the exchange colour space. This is "the one eyed in the island of blinds" and hence a reasonable estimation for a print service provider active in digital printing. In other regions, such as North America or Japan, printing conditions similar to the ones defined in ISO 12647-2 are used ("GraCol2006" or "JapanColor 2001 coated"). With respect to separation a moderate GCR has been used when building the ICC output profile "PSOCoated V3 (ECI)" based on FOGRA51. In order to reflect the most relevant channel specificity, here a maximum TVS of 300% is already built into the "default" PSO Coated V3 profile.



EXCHANGE?

It is envisioned to have a small number of "unified" (agreed upon) process independent char.-data sets. Currently ICC and Fogra work on creating a large gamut colour space that can be used for printing conditions with a larger gamut than FOGRA39.

The second case reflects all circumstances where print service providers receives print data that can be deleted right after printing. That means that all the beforementioned precautions are not relevant and the separation can focus on the strengths and weaknesses of the actual printing condition (APC). The most important transformations are a stronger GCR and a TVS reduction.

Both cases provide an easy relation to creation or prepress on the one side and print on the other. Figure 2.16 provides a general workflow diagram or flow chart that follows that paradigm by means of three different use cases namely:

1. Data preparation (gamut mapping & separation)
2. Process conversion
3. Optional separation adjustments

The workflow starts at the top left and ends with the print output on the actual printing condition (APC).

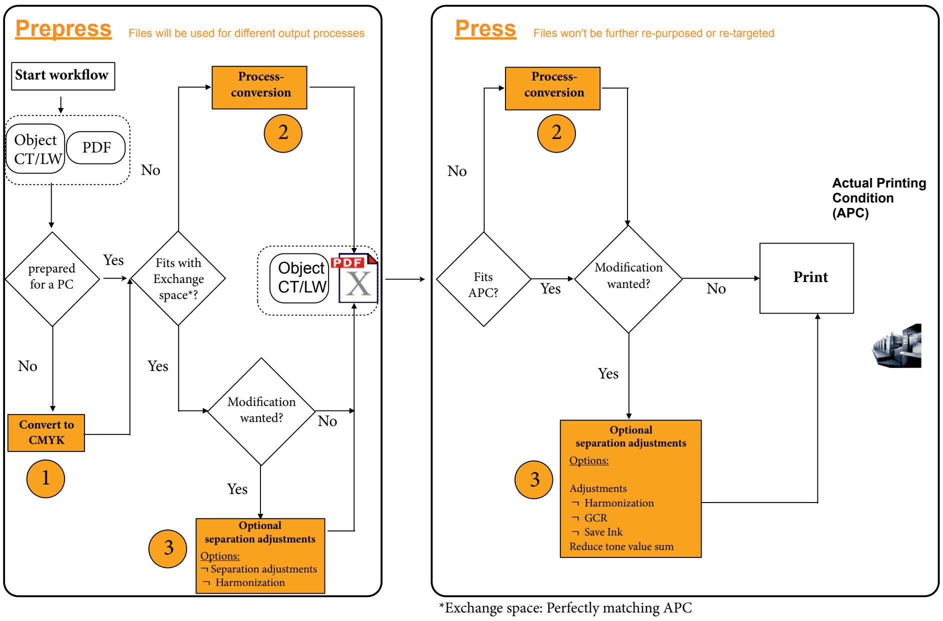


Fig. 2.16: Flow chart of a generalized workflow that illustrates the separation between prepress and press in a post film based workflow world. Three important use cases are depicted whereas the concrete test criteria can be found in the reserach project (Fogra Nr. 10.049). CT: Continuous tone; LW: Line Work.

EXPERT

More information on how to scrutinize DeviceLink transformations including test forms and evaluation programs can be found on the Fogra webpage: https://fogra.org/en/research/prepress-technology

2.5.3 Overprinting and Transparency – Roadblocks for daily production

The interaction of PDF-graphic elements

A variety of data formats and structures are used for the creation of this type of material, but with two prevalent kinds of underlying data structures. These are vector-based data for the encoding of line art and textual information and raster-based data for the encoding of image information, including previously rasterized line art and textual information. For more information about the graphic elements, their overprinting characteristics and the PDF transparency model the reader should consult the PDF specification. However the complexity of this topic is addressed by ISO 15970-7, specifying the use of the Portable Document Format (PDF) Version 1.6 for the dissemination of digital data intended for print reproduction by means of PDF/X-4, by simply saying:

> "Amongst other things, transformations between colour spaces affect colour reproduction, overprints, trapping, transparency and smooth shading."

The PostScript and PDF bible intensifies this by saying:

> "Using typical layout applications it is almost impossible to gain an understanding of the complex interaction of the different elements by means of their final visual appearance. So it should be possible for the user to identify how the colour management settings affect the appearance of an individual object ..."

Practical tips for dealing with overprinting objects

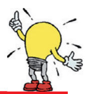
The overprint characteristics or rules determine the final appearance of objects being placed on a page. These rules are governed by many factors such as the colour space encoding and it's polarity (additive or subtractive) as well as the content of each channel. For instance the overprinting rules of DeviceGray and DeviceCMYK differ when overprint mode (OPM) is set to 1. In that state DeviceGray will continue to knock out all of the CMYK channels of any underlying element, whereas an element defined in DeviceCMYK (other than an image or smooth shading) will only knock out of underlying elements in those process colorants where the colour value in the overprinting element is not zero. So the effect of a colour transformation such as a DeviceLink transformation (on a object by object level, e.g. to save ink) might significantly affect the appearance of a element if a channel changes it value from zero to a non-zero value. In order to avoid such problems a few hints should be given:

¬ Visual check by means of the Acrobat overprint preview
¬ To report overprinting objects by means of a preflight check

How to deal with objects using live transparency

The need to handle transparency and transparency effects (such as drop shadows) for images, text, and line art is standard practice in high-end prepress environments. With Acrobat 5 (PDF version 1.4) Adobe introduced in 2001 the notion of transparency. Transparent objects do not necessarily obey a strict opaque painting model but may blend (composite) in interesting ways with other overlapping objects. The new transparency model allows you to optimize certain existing workflow practices. For instance, you are probably using Adobe Photoshop to add drop shadows to type and vignettes to images. With a tool such as Illustrator 9.x, you can apply effects like these directly to the affected objects. In addition, the effects remain "live" so that when type is edited, for example, the applied drop shadow changes with it.

Like any new technology, however, the upgraded transparency capability also exposes different and sometimes unfamiliar results across applications and file formats that might compromise the blind data exchange.



TIP

For information on designing with transparency and software-specific controls, see "A Designer's Guide to Transparency for Print Output" at https://help.autodesk.com/sfdcarticles/attachments/Adobe_Whitepaper_on_Transparency.pdf

The rising problems related to transparency are caused by layouts that are becoming more and more complex. A given object shall be composited with a backdrop. Ordinarily, the backdrop consists of the stack of all objects that have been specified previously. During the compositing of an object with its backdrop, the colour at each point shall be computed using a specified blend mode, which is a function of both the object's colour and the backdrop colour. The 16 blend modes determine how colours interact; different blend modes may be used to achieve a variety of useful effects. The Altona Test Suite covers an extensive overview of the different blend modes by means of a systematic arrangement of the important colour spaces.

TIP

ATS 2.0 Technical Page checks all important blend modes and thus allows for a exhaustive check of your workflow capabilities.

Depending on the used RIP software of the print service provider it might be possible that life transparency is not supported or simply not understood. For this reason, PostScript (desktop) printers, Adobe PostScript Level 2 high-end printers, and most Adobe PostScript 3 high-end production devices and RIPs cannot accept and process "live" transparency information on the fly. To print correctly, all transparent objects in a graphic must, at some point in every workflow, be flattened. Flattening converts the objects from a device-independent format into a format that is visually equivalent but does not contain transparency; this format can be represented in PostScript. At its simplest, the process of flattening converts all the overlapping elements in a stack of transparent objects into a format that captures the look of the original transparency for printing including the integrity (e.g. text stays text) of the artwork.

Applying colour transformations such as DeviceLink transformations before the flattening process the final transparency effect might be totally different, particularly when blend modes are used that are case sensitive. For instance a replacement of the OutputIntent profile by means of an alternative ICC profile that is based on the same characterization data set might lead to a somehow different separation and hence to different blending effects. This example is also checked by the Output Intent indicator being part of the ATS Technical V.2. Another problem might be the colour transformation that is applied differently for raster and vector objects. Especially after a flattening process vector objects might be rasterized that lead to different colours for objects being placed next to each other. Therefore it is recommend to apply a DVL-transformation consistently to both vector and raster objects. Practical tips and general guidelines for reliable creation and output of transparent documents can be found in chapter 3.

It should be clear that Fogra recommends to use technology that allows for a native interpretation of transparency rather to use technology to "downgrade" your documents. However since a lot of service providers need time for the transition, chapter 3 offers two workflows (V1.4 and V2) that addresses both use cases.

Altona Test Suite 2.0 – „Technical Page 2"

In addition to targeting features introduced in PDF/X-4 such as transparency, OpenType fonts, optional content (also known as layers), page sizes beyond 5 by 5 meters, JPEG2000 compression and more, the Altona Test Suite 2.0 Technical Page also extends a number of tests that would have already applied to PDF/X-1a and PDF/X-3, for example more extensive coverage for smooth shades or PostScript and TrueType fonts than was available in Altona Test Suite 1.0 through 1.2. The Technical Page of the Altona Test Suite 2.0 aims to address the needs of all parties involved in the production and processing of PDF/X-4 files. The test page contains a sequence of patches where each patch allows a relatively easy and straightforward assessment of the quality of output generated from a PDF/X-4 file.

The test form alongside a detailed documentation can be found at the ECI webpage www.eci.org.

Altona Test Suite 2.0 · Technical Page · template for evaluation – Please mark your findings (X))						
Patch	No issues	Very small de-viations, but still acceptable	Deviations that may or may not be acceptable	Clearly unacceptable deviations	Some or all of the patch not rendered at all	Remarks
A						
B						
C						
D						
E						
F						
G						
H						
K						
L						
M						
N						
P						
Q						
R						
S						
T						
V						
W						
X						
Z						
Σ						

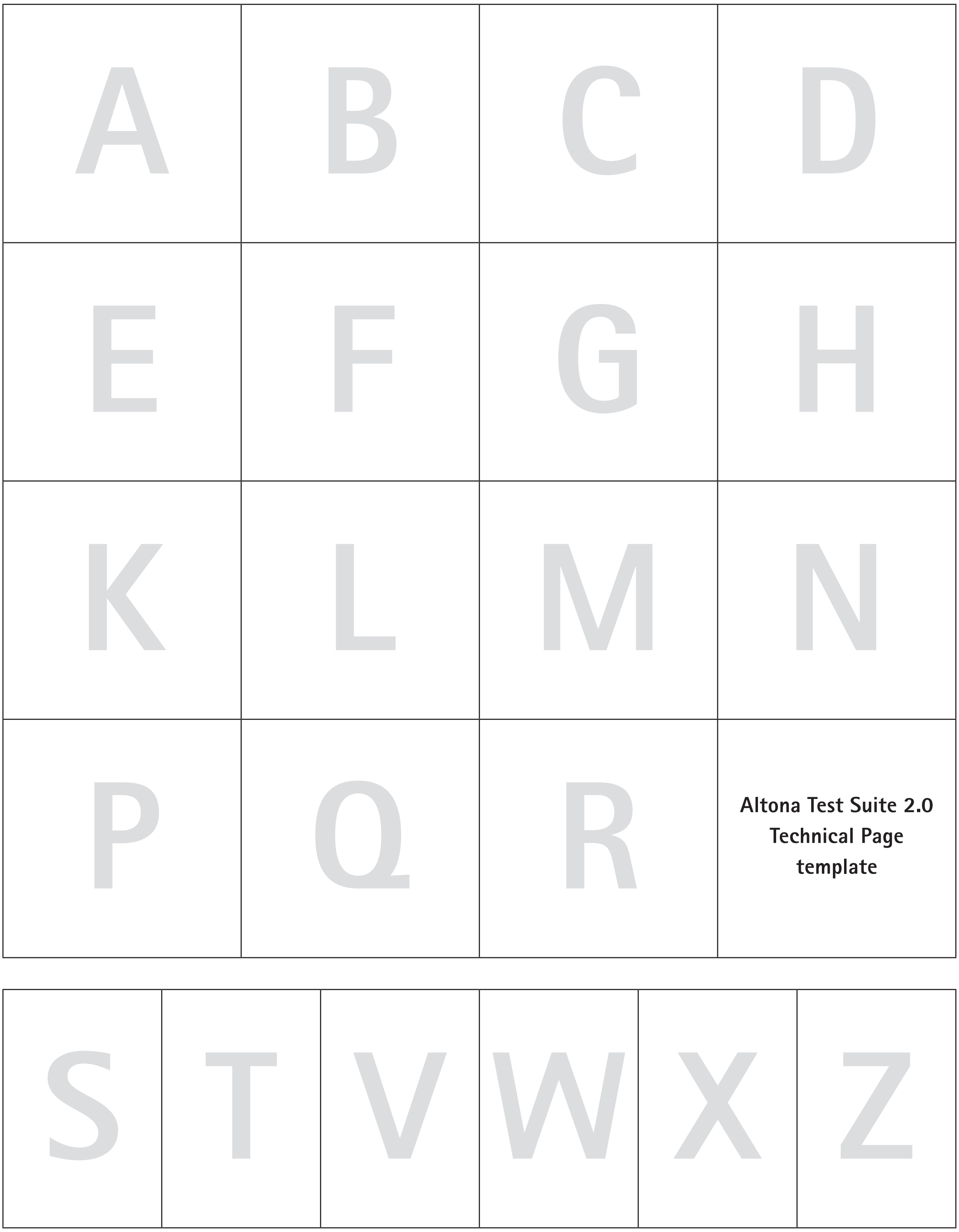


Fig. 2.23: Overview of the test areas A to Z used by the ATS technical V2. It is intended that the letters I, J, O, U and Y are missing.

2.5.4 PDF and PDF/X

PDF was developed and specified by Adobe Systems Incorporated beginning in 1993 and continuing until 2007 when this ISO standard was first prepared. The Adobe Systems version PDF 1.7 is the basis for ISO 32000 Part 1. This document is ISO 32000 Part 2 which is a self contained replacement for Part 1 and specifies PDF 2.0.

The goal of PDF is to enable users to exchange and view electronic documents easily and reliably, independent of the environment in which they were created or the environment in which they are viewed or printed. At the core of PDF is an advanced imaging model derived from the PostScript® page description language. This PDF Imaging Model enables the description of text and graphics in a device-independent and resolution-independent manner at a complete, precise and professional level. Unlike Postscript, which is a programming language, PDF is based on a structured binary file format that is optimized for high performance in interactive viewing. PDF also includes objects, such as annotations and hypertext links, that are not part of the page content itself but are useful for interactive viewing and document interchange. PDF files can be created natively in PDF form, converted from other electronic formats and since it supports a wide range of image and compression technologies, is a suitable format for documents digitized from paper, microform, or other hard copy formats. Since its introduction in 1993, aided by the explosive growth of the Internet, PDF has become widely used for the electronic exchange of documents in the graphic arts.

ISO 15930-x – The PDF/X-family

In order to achieve a level of exchange that avoids any ambiguity in interpretation of the file, a limited set of PDF objects that are permitted to be used is identified and restrictions to the use, or form of use, of those objects, and/or keys within those objects are added. The various parts of ISO 15930 define a number of conformance levels intended to address different requirements; all define data formats and their usage to permit the predictable dissemination of a compound entity to one or more locations.

In order to maximize consistency the exchange needs to be restricted to CMYK (and spot colour) data, whilst in others environments it is more appropriate to convey it as colour-managed, CMYK, gray, RGB, and/or spot colour, or to use.

Based on the different conformance levels ranging from PDF/X-1a to PDF/X-5 two levels can be considered to be most appropriate for nowadays high quality printing namely:

- PDF/X-1a for classical workflows using CMYK and Spots (ISO 15930-4)
- PDF/X-4 for modern workflows that allow native transparency and colour management (ISO 15930-7)

PDF/X-4:2008 versus 2010

Adobe uses the publication years of the pertinent ISO standards to reflect the pertinent standard when exporting PDF files in InDesign. Indeed for PDF/X-1a and PDF/X-3 there are two part of ISO 15930 namely

- PDF/X-1a:2001 defined in ISO 15930-1
- PDF/X-1a:2003 defined in ISO 15930-4
- PDF/X-3:2002 defined in ISO 15930-3
- PDF/X-3:2003 defined in ISO 15930-6

However for PDF/X-4 the 2010 revision has replaced the 2008 one. Therefore PDF/X-4 doesn't need an additional publication year in its designation.

Hint:

The English term "trapping" (as used in the PSD trapped key) is prone to be misunderstand. Reason for that is the the ink trap is also termed trapping. Contour trapping and ink trapping should not be confused.

Extending PDF/X-standards by job specific requirements

Whilst the PDF/X standard provides a basis for the basic checks for print ready documents there are a some additional parameters that can't be defined in ISO 15930 but which are important for sector specific printing. In order to express such a set of additional, print sector specific requirements the so called PDF/X-Plus Standard has been evolved. Typical requirements are:

¬ Minimal image resolution,
¬ Maximum Total ink coverage (TVS),
¬ Minimal width of hair lines,
¬ Overprinting objects,
¬ Number of spot colours,
¬ The usage of suitable output intents

Long story short, PDF/X relates to general print-ready requirements whilst PDF/X-Plus reflect sector specific requirements such as the PDFX-ready preflight profiles that are fully supported by Fogra and recommended by the PSD.

2.5.5 Device or simulation mode? – The importance of the correct data driving

Contrary to standardized offset printing, digital printing uses two fundamental types of transformations. Data prepared for given standardized conditions can be used for both printing and proof making. In other words, due to the similar solid coloration within one printing condition (paper type) the reproduction of technical tones will be very consistent. For instance a red gradient, created by using only Yellow and Magenta, results in a similar appearance across similar papers, printing machines and printing inks. That implies the appropriate RIP-correction by means of four 1-dimensional curves. This kind of transformation is characterized by „pure" reproductions. In order to specifically allow for such a reproduction the so-called "device mode transformation" has been defined in ISO 15311. It defines a transformation of device colour values (tone values), where each colour channel is transformed independently of the colour value of other channels. For an n-channel device, n single-dimension transforms are applied some of which may be identity transforms. This is sometimes called native or calibration mode.

A channel does not necessarily correspond to a colorant. For example a printer with cyan, magenta, yellow, black, light cyan and light magenta inks (CMYKcm) might be driven with 3 (typically RGB) or 4 (typically CMYK) channels where a single channel (C, for example) is mapped to more than one colorant (cyan and light cyan). The concrete mapping between the channels and the colorant might not always be accessible to the user interface or the front end.

This way of data transformation, i.e. using gradation curves, typically won't result in a proof-to-print match when digital printing comes into play. That relates to the fundamental differences with respect to the used printing inks, substrates and imaging processes. In particular the printing inks severely defer from those defined for offset (ISO 2846-1). That effect is visualized in Figure 2.17.

Fig. 2.17: Simulation of the resulting colour appearance, when offset data is used for output „1:1", i.e. based on four 1-dimensional curves ("Device Mode Transform") on different digital printing systems. Source: CGS

In addition the device mode transformation allows for dedicated diagnosing of digital printing machine capabilities – which are independent of the printing condition to be matched. Such capabilities comprise the achievable resolution or image sharpness, the homogeneity of the individual colour channels or the analysis of the tone value reproduction values.
Since a categorization of these plethora is far from being practical, de-facto printing conditions (known as exchange spaces) such as FOGRA51 will be used as the reference. That relates to a requirement typically in the realm of the lite production printing to "match offset".
In order to solve that problem, data transformations of device colour values are needed that aim to closely match the intended or reference printing condition. That means that pure colours, also known as technical tones, might be printed with a mixture of the colorants used in the individual digital printing system. This multi-dimensional transformation (cLUT) is called "simulation mode transform", since it tries to reproduce the reference as closely as possible. While this method typically satisfies the colorimetrical requirements it causes impressions of noise, which is mostly not in accordance with the users expectation. This also refers to black text, which should be printed with the black colorant only and not with a mixture of colorants, as this can cause coloured fringing.

Colorimetrical Match while keeping pure colours – An oxymoron?

Depending on the used screening method, colour transformations that lead into spot colours being reproduced as tint values or "pure" colours being "contaminated" with secondary colours might result in customer complaints despite the fact that a colour match is achieved. This problem relates to screening methods in combination with the underlying imaging process that makes use of large halftones, which are visible to the naked eye. They will be perceived as graininess or noise, especially pronounced in the reproduction of skin colours.
Those structural limitations of the printing process face the print service provider to make a decision off between the required colour accuracy and a high level of channel preservation ("keep purities"). While there are mechanisms in place in many PDF RIPs to allow channel preservation at the time the PDF is processed for output, there are presently no mechanisms which allow the PDF content creator to specify channel preservation at the time of PDF creation when a colour managed workflow is desired.
The print service provider is advised to judge the colour coordinates of the primary and secondary colours both for the actual printing system and the reference printing condition. The more the used primary colours of the respective printing system differ from those of the reference, the greater this discrepancy is. Thus a spiderweb-diagram could be used to visualize this. The optimal result requires some testing by means of the setting for the re-targeting transformation. That is described in chapter 5.

2.5.6 Detail sharpness – Confusing resolution and addressability

It is obvious that resolution or resolving power is an important aspect of image quality. But did you ever wonder why black type is easier to read than grey type? They both have the same spatial resolution. Discussing the resolution of printed matter or a printing system therefore needs prior agreement and understanding of the used terms. Resolution can be defined as a measure of the ability of an input device to record, or an output device to reproduce the fine detail of an image. Although this is a correct definition, the contrast must also be taking into consideration if detail sharpness is of concern.

Many conventional printing processes can only print a constant layer of ink. So the maximum resolution can be achieved when primary colours are printed with the native addressability, e.g. 2540 dpi (=1000/cm) for offset printing. A cyan line or black text have a minimum line width of 10 µm. As soon as continuous tones of one ink (or colours using more than one colorant) are required a screening process is needed to use the spatial resolution to mimic different tone levels. Hence halftone cells, that are much bigger than the minimum line width, are needed to "shape" the requested tone level. For a screen frequency of 60/cm (150 dpi) a halftone cell is 1/60 cm=167 µm and that means the halftone dots reduce the perceived resolution. Just take a magnifier glass and compare a 100 K line with a line of CMYK=20,30,60,20.

Printing processes, especially inkjet or toner based ones, are able to print more than one layer of ink. This is called multi-level printing (instead of binary level printing). Halftone cells can become much smaller again in order to "shape" the required tonal levels. In order to print many tonal steps, which is a key requirement of a high overall image quality, both the spatial and the density resolution interact and determine the final print quality. For raster images it is therefore possible that a 300 dpi (spatial resolution) can print images as sharp as an offset print that needs 2540 dpi. This is doable since the density resolution is much higher. Typical grey scale inkjet heads can print 3 to 6 different drops and therefore density levels. However, for line art such as fine lines or a bar code the restricted spatial resolution still applies.

This emphasize the importance of the correct data interpretation. On the one hand the interpretation of the print elements among each other (aka RIP resolution) and on the other hand the imaging resolution (aka addressability).

Hint:

Due to performance reasons the RIP-resolution is often smaller than the imaging resolution. However it is advisable to use reasonable ratio between them. For proofing devices the RIP resolution is typically 720 dpi and the printing resolution 144 dpi..

Resolution of print data:

The required resolution of print elements (raster) depends on the following factors:

- Type of application and demanded quality (e.g. High End fine art versus a flyer)
- Intended viewing distance:
  - The optimal viewing/reading distance is typically as long as the diagonal of the media format of the printed product
  - A banner comprising a diagonal of 3,5 m will be typically viewed from 3,5 m – in order to perceive it as an entire image (like the first row in the cinema). That relates to image resolution that might be significantly lower than the often used 300 dpi.
  - However the minimum viewing distance is the governing factor that needs to be taken into consideration when preflighting data for large format printing. If the reading distance (typically 40 to 60 cm) is of importance, then the normal preflight rule of thumb is recommended (to use 300 dpi). Here digitally printed wall papers are a good example for large format application requiring a high resolution.
    That's why the intended viewing distance needs to be communicated between the print buyer and the service provider.

- ¬ ISO candidate 15311-3 provides three predefined viewing distances namely 50 cm (normal: reading distance), 1 m (POP, Point of purchase) and 1,5 m (banner). In addition the knowledge of the intended viewing distance allows a reasonable evaluation of other print quality attributes such as graininess.
- ¬ Modern preflighting tools allow for using variables. Here the use can input the scaling factor and the intended viewing distance and the software uses the corresponding minimum resolution.

¬ Substrate and printing process:

- ¬ Some large format printers have a low addressability of about 300 dpi (and only binary printing heads). That means that huge data won't automatically result in better image quality.
- ¬ Mesh like substrates also reduce the apparent resolution

¬ Difference between relative (effective) and actual (intrinsic) resolution:

- ¬ The actual resolution is the intrinsic resolution of a print element defined as dots per unit length, e.g.:
  – dpi = dots per inch (1" = 2,54 cm)
  – ppi = pixel per inch (typically used for resolution of print elements)
  – lpi = lines per inch (typically used for defining the screen frequency e.g. 150 lpi)
- ¬ The actual resolution becomes more meaningful if the final scaling factor and the intended viewing distance is known. Incorporating the scaling results in the effective resolution. An image with a intrinsic resolution of 300 ppi (but scaled about 200%) as an effective resolution of 150 ppi.

As prescribed the final detail sharpness is influenced by more factors such as the print speed, the number of passes (in case of inkjet printing with a sleight), potential mis-registration, heating settings (for solvent printers) or the printing direction (uni- or bidirectional). These factors constitute the print mode which is a paramount part of the so called "combination".

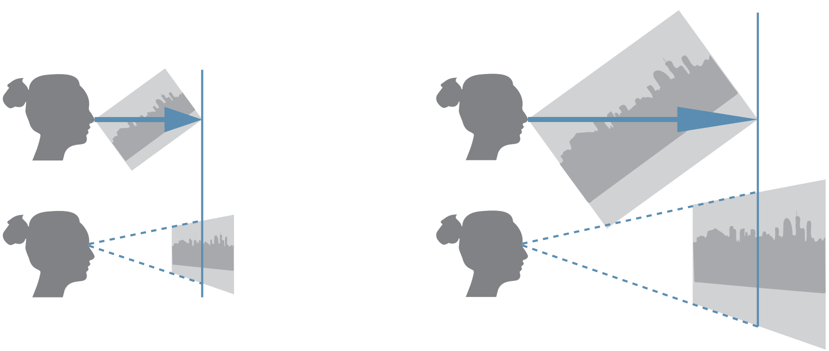


Fig. 2.18: The typical viewing distance can be derived from the diagonal of the final product. Typical viewing distances are: Reading distance (50 cm), Point of purchase (1 m) and Large format applications (> 1,5 m).

Application	Image-diagonal	ppi for 1:1	ppi for 1:10 (scaling)	File size per qm
Large Format Poster prints (normal viewing distance)	1 – 2 m	100 – 150	1.000 – 1.500	15 – 33 MB
	2 – 5 m	60 – 75	600 – 750	5 – 8 MB
	> 5 m	45	450	3 MB
Large format banner or signs (large viewing distance)	2 – 5 m	50 – 60	500 – 600	4 – 5 MB
	> 5 m	30 – 40	300 – 400	1,5 – 2,5 MB
Large format High End (Reading distance)	ab 1 m	150 – 300	1.500 – 3.000	33 – 133 MB
more to come				

Tab. 2.9: Recommendations for minimum image resolution of print elements for typical applications.

2.6 Evaluating print image quality

A large number of measurement methods are available to describe attributes of print image quality. Many of these provide a measure of particular image quality attributes, often using completely different numerical scales. With few exceptions, such tools provide no clear correlation with visual perception in order to establish the visual significance of a measured difference. Some of these methods have been developed without reference to digital marking technologies, so they allow for device independent measurement of image quality attributes. These evaluations are complex, subject to perception variations amongst individuals and multiple parameter considerations. ISO 15311 is intended to provide a basis for practical, objective means of communication, describing basic image quality parameters.

Identify and evaluate image quality

The evaluation of print image quality is an active field of research. However by using a dedicated set of quality measures and related aim values and tolerances there are methods available that will be used in that standard to achieve and reflect industrial printing practice. Whilst some attributes can be evaluated and qualify/codified without a specific reference (such as the mottling or graininess) other requirements need dedicated references (beside aim values and corresponding tolerances). The colorimetric aim values of the image content are an example for the latter one. Print image quality should be separated from image permanence or durability requirements, which are important for the final product but not primarily related to the perceived image right after printing.
ISO 15311 is process independent, in line with the move in the printing and publishing industries to use electronic data for content storage and data exchange throughout the print production process, from concept development to finishing. The economics of digital content creation and production preclude upstream data preparation for all intended printing conditions, including analogue and digital processes. The final output conditions for print products, ranging from printed cups to large format banners, are often not known at the time of creation. Prior definition of expected image and product quality can be based on specific print image quality criteria. These criteria address colour rendition, homogeneity (uniformity), resolution, artefacts, in addition to permanence aspects such as light fastness or rub resistance.

The central point is the human perception

The final judge about the image quality is the human observer. And all metrics have to be evaluated against the visual perception. In other words image quality is the sum of the weighted perception of human observers to one or more visual stimuli. Evaluation image quality strongly depends on the presence of an (physical) original. The nature of graphic arts workflow can be summarized as so called full reference workflows. Here the original is defined by means of a contract proof (see ISO 12647-7), validation print (see ISO 12647-8) or a softproof (see ISO 14861) which has been approved by the creator (print buyer). The print service provider needs to make sure that the chosen reference is technical achievable for the selected application.
Zero reference workflows, such as printing a photo book, are more complex to handle since the reproduction must be compared against a mental reference. This includes the identification of users preference and will not be covered here. Strictly speaking the usage of off-press proofs are "reduced reference" scenarios since only the colorimetrical accuracy is defined but not the screening, paper structure and haptic or potential bronzing. Here an on-press proof is needed.

Print image quality requirements in the graphics art industry

Going from image quality to print image quality should be discussed in the following paragraph. Instead of using a coherent print image quality system the graphic arts industry has been pragmatically concentrated on using a selection of individual quality attributes that is understood and measurable. Basically it can be said that the print image quality is determined by three different categories namely colour reproduction, detail sharpness and homogeneity. Tab. 2.7 summarizes established print quality attributes and groups them accordingly.

Category	Quality criteria	Typical Evaluation
Colour reproduction	¬ Total area coverage ¬ Colorimetrical and densitometrical deviations ¬ Print curves ¬ Colour gamut ¬ Agreement of solid coloration and tone value increase according to ISO 12647-2	¬ Colour measurements of control bars and test charts
Detail sharpness	¬ Addressability ¬ Tone value reproduction limits ¬ Tone value differences ¬ Mis-registration: “image-to-image”, “image-to-edge” or “frontside-to-backside	¬ Siemens star (visual) ¬ Control bar (visual) ¬ Crop marks (visual and instrumental) ¬ Line blurriness and raggedness
Homogeneity	¬ Uniformity across the forma ¬ Uniformity across the print run ¬ Streaks (stripes) in uniform areas	¬ Density profiles ¬ Instrumental (9 Point-measurement according to ISO 12647-7 ¬ M-Score according to ISO 15311-1

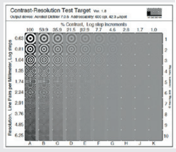
Tab. 2.10: Typical print related attributes and their corresponding category.

Evaluation of the perceptual resolution (L-Score)

The evaluation of perceived image quality in prints is an active field of research. Definitions of measurements of print quality attributes that correlate with visual perception by technology-independent means, even across many printing technologies, is under current scrutiny. It is influenced by a number of different quality attributes that are, for convenience only, categorized into colour and surface finish, homogeneity, perceptual resolution and artefacts.

ISO 29112 says that printer resolution, a quantification of the ability of a digital printing system to depict fine spatial detail, is a perceptually complex entity with no single, simple, objective measure. It further defines 5 print quality characteristics namely: native addressability, effective addressability, edge blurriness, edge raggedness, and the printing system modulation transfer function (MTF) that somehow contribute to the perceived resolution. However previous research at Fogra indicated, that a test target comprising a reasonable amount of patches, each of which contains spatial patterns (e. g. concentric circles) of varying line width and contrast, provides a very high correlation with the perceived resolution. Based on an existing test target (RIT Contrast-Resolution Test Target) an abridged method for determining the perceptual resolution termed "L-Score" of printed matter was developed and will be proposed for further analysis and inclusion of ISO 15311 to be part of the system check evaluation. Further studies are needed to extend the scope toward different colour centres both along the grey axis and within the colour space and a case (patch) depending evaluation of non-standard aliasing pattern. Since the evaluation requires image processing the method can't easily be provided as an Excel spreadsheet. However it is planed to provide an executable file that allows testing the L-Score.

L-Score:
In this case the RIT Contrast-Resolution Target is used to measure the L-Score.



Defining resolution

The majority of means to define resolution dates back to the photography and optics area. Here the resolution is defined as follows: Two parallel lines, with equal widths, being separated by a blank space of the same width are resolved if they can be seen as being different, see Fig. 2.18. The resolving power will then be defined as the inverse, e.g. in linepairs or cyles per mm. If the viewing distance is also incorporated the resolution can then be defined as cycles per visual degree (field of view). The normal eye can separated a black-white linepair being separated by a visual angle of 0.025°. For coloured ("low contrast") line pairs the value is higher, hence the resolution worse.

That principle is embodied in the RIT contrast resolution target. The resolving power is better for the black and white (100 % and 0 %) than for dark grey and light grey (80 % and 20 %).

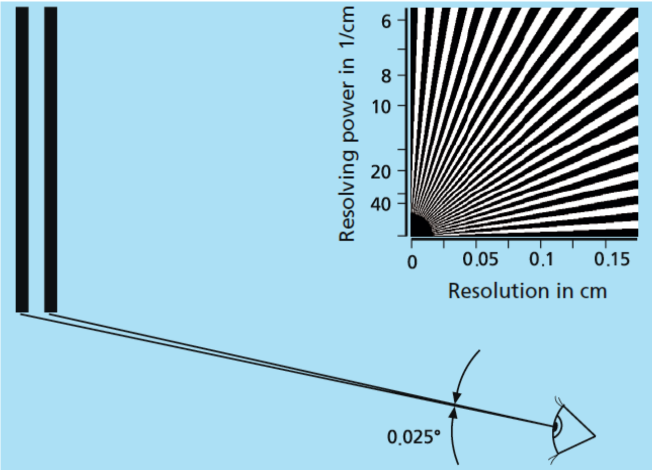
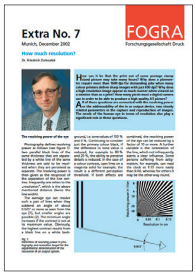


Fig. 2.19: Definition of the resolving power originating from photopraphic and optical applications. The Siemens star is often used as a visual control element to be judged for that resolution where the rays are not resolved anymore.


Extra No. 7
Munich, December 2002
How much resolution?
FOGRA
Forschungsgesellschaft Druck

More information can be found in Fogra-Extra Nr. 7

Image, Edge and Line-sharpness

The attributes described in this section are believed contribute to resolution perception. They are part of the so called system check hence to be evaluated for an entire system rather then for each individual print job.

Line width

Minimum line width is a measure of the ability of a digital printing system to print fine detail. Where this measure is reported the minimal width of the line measured normal to the line from edge threshold to edge threshold as defined in ISO/IEC DTS 24790 shall be used.

EXAMPLE Minimum line width: 0.12 mm (K), 0.15mm (CMY).

NOTE This metric can be used to define the (inter) colour bleed.

Native addressability

This measure is often called 'resolution' which in most cases is very misleading as it does not usually correlate well with perceived resolution or image sharpness. This measure should not be reported as an image quality metric. If this measure is reported the native addressability, which is the inverse of the minimum pitch between adjacent spots that can be independently controlled and produced by the printer, shall be reported as define in defined in ISO/IEC DTS 29112.

EXAMPLE Native addressability: 2360 lines per mm.

Effective addressability

The effective addressability is a measure of a digital printing system's ability to produce sharp images. When effective addressability is reported the method defined in ISO/IEC DTS 29112 should be used.

EXAMPLE Effective addressability: 2360 lines per mm.

Raggedness

Raggedness is a measure of a digital printing system's ability to print elements with straight edges or smooth curves such as text characters. The appearance of geometric distortion of an edge from its ideal position is called raggedness. A ragged edge appears rough or wavy rather than smooth or straight necessary define the permissible amount of streaking.
Where raggedness is reported, the standard deviation of the residuals from a line fitted to the edge threshold shall be measured using the method defined in ISO/IEC DTS 24790.
EXAMPLE Raggedness: 0.062 mm.

Blurriness

Blurriness (inverse of sharpness) is a measure of prints from a digital printing system being hazy or indistinct in outline. Where blurriness is reported a noticeable transition of blackness from background to character should be measured using the method defined in ISO/IEC DTS 24790.
EXAMPLE Blurriness: 0.2 mm.

Evaluation of homogeneity

Homogeneity (uniformity), refers to the subjective impression of colour uniformity across a large image that is intended to have a uniform colour. Colour uniformity refers to all types of colour variation: lightness, hue, saturation or derivatives of these measures separately or in combination. All types of colour variation are taken into account including, but not restricted to: 1D, 2D, periodic, aperiodic, localized, large-scale, and small-scale variation, separately or in combination such as streaks, bands, gradients, mottle, and moiré.
The reference is always the tone value (e.g. CMYK or RGB) defined in the original data set. Basically all forms of inhomogeneity can be separated to be either periodic or aperiodic. 1-dimensional non-periodic patterns are called streaks while the appearance of 1-dimensional, periodical bands within an area that should be homogeneous is called banding. Non-periodical appearance of macroscopic inhomogeneities are often called mottle or unwanted reflectance variations.
ISO/CD 15311 defines the following metrics to be used for the system check:

- Streakiness
- Graininess as defined in ISO/DTS 24790
- Graininess as defined by the P-Score
- Mottle as defined in ISO/DTS 24790
- Mottle as defined by the M-Score
- Inking variation across the format and in the printing direction

2.7 Important printing technologies

2.7.1 Introduction

The following sections explain the basics of the two most important digital printing technologies. This is inkjet printing and electrophotography. The focus lies in the basic understanding to better understand process control approaches and not an in-depth understanding of the pertinent technology. For this purpose the relevant literature should be consulted.

2.7.2 Inkjet Printing

Basics of inkjet printing

The basic principle of inkjet printing is simple: a print head transfers small ink droplets (dots) through a nozzle onto the substrate to be printed. In most cases, the printer controls two motions in the process: the lateral motion of the print head and the vertical motion of the print media.
A special feature of inkjet printing is the contact less transfer of the ink to the material, which also makes it possible to print on uneven, structured surfaces.
The two main techniques are Bubble Jet (thermal inkjet) and Piezo Inkjet. Both techniques are used in large format systems with widths of up to five meters and in small desktop inkjet printers.

Examples:

HP OfficeJet 6500

Epson Stylus Pro GS 6000

Bubble Inkjet (thermal)

The water-based ink is heated up very quickly to about 400°C by the heating element in the print head. The resulting vapor bubble shoots ink droplets from the nozzle onto the print media. The droplet size is physically preset and thus non-variable. The effects of heat on bubble jet print heads bring about faster wear and therefore they have to be replaced frequently. In the case of small desktop printers, this problem is solved by the complete (and costly) replacement of the print head and ink cartridge. This technology can be used only for water-based inks

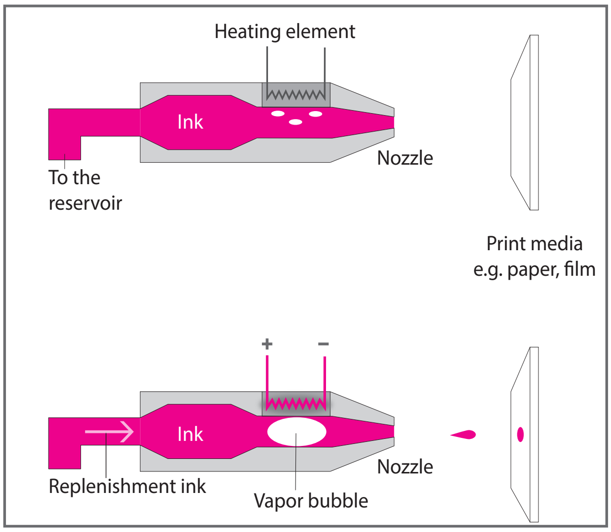


Fig. 2.20: Bubble Inkjet (Thermic)

Piezo Inkjet

These printers make use of the piezo ceramic property to deform under voltage variation: an electrical pulse changes the shape of the piezo element. This change in shape creates a pressure pulse in the ink channel, which leads to the ejection of an ink droplet at the nozzle. The size of the ejected droplet can be controlled very precisely by means of the electrical pulse (variable dot size). Piezo print heads are theoretically indestructible because they are not exposed to any thermal load.

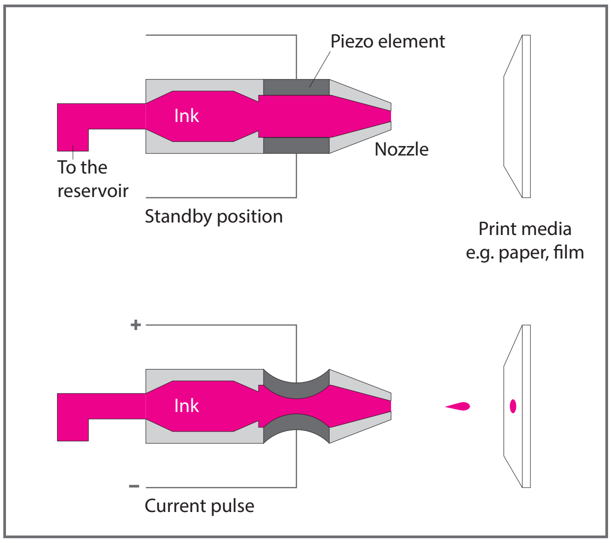


Fig. 2.21: Piezo Inkjet

Ink systems

Using the bubble inkjet (thermal inkjet) and piezo inkjet printing technologies different printing materials are printed on with different inks:

- Water-based inks
- Solvent-based inks (solvent or eco-solvent)
- UV-curable inks
- Latex inks
- Dye-sub inks

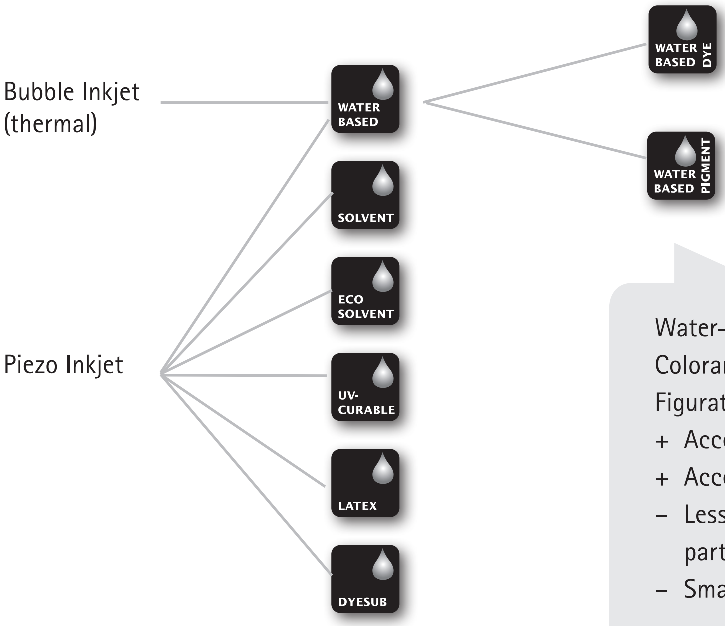
Their differences and use cases as well as the corresponding pros and cons will be explained now.

Thermal print heads only work with water based inks.
Piezo technology is used for all other inks

Schematic representation:

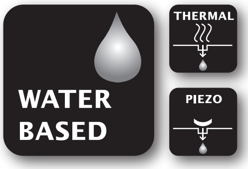
Water-based dye inks:
Colour completely dissolved in water

Figuratively speaking: "sugar water"
+ Brilliant colour reproduction due to closed surface
– Low UV resistance
– Non-waterproof



Water-based pigment inks:
Colorant particles are dispersed in water
Figuratively speaking: "sand in water"
+ Acceptable water resistance
+ Acceptable UV resistance
– Less brilliant, duller impression due to large particles that do not yield a smooth layer
– Smaller color space than dye inks

The ink systems differ in size (printing width), quality and application due to their properties:

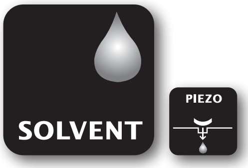


Very high quality (in terms of color space and resolution) can be achieved with water-based ink systems – ideal for art reproduction, proofing and indoor applications in general as well as for closer viewing distances. However, water-based inks only bond with specially coated surfaces really well and are only suitable for outdoor use to a limited degree. In turn, the printers are easy to handle and in addition to machine shops are often also used in offices.

Printing widths: 61 cm to 152.4 cm

Principal use: Fine art, posters, indoor banners

+ Large colour space
+ Simple processing, no health risk
+ Reasonably priced
– Low UV resistance
– Low water resistance (outdoor use is limited)
– Only print media with special coating



If prints need to be especially durable and are used outdoors, solvent or real-solvent inks, i.e. solvent-based, are used. These inks dissolve the substrate and bond with the print media, which means that solvent prints are very durable. The drying process is carried out with a heater (pre, main and post heating). However, a health risk is involved with solvent inks and they cannot be used in rooms without special ventilation equipment

Printing widths: 137.2 cm to 500 cm

Principal use: Tarpaulins for outdoor use, car wrapping, signs

+ Extremely durable (UV-resistant, water-resistant, scratch-resistant)
+ Suitable for outdoor use
+ High print speed
+ Low drying time
– Relatively expensive printers
– Protective measures required when handling
– Can only be used with a ventilation system
– Inks are hazardous to health

Eco-solvent or mild-solvent printers solve the emission problem in part: the inks are far less harmful to health and the environment but have similar drying properties and durability.

Printing widths: 75 cm to 260 cm

Principal use: Tarpaulins for outdoor use, car wrapping, wallpapers, flags, signs, stickers
+ Very to extremely durable (UV-resistant, water-resistant, scratch-resistant)
+ Suitable for indoor and outdoor use
+ High print speed
+ Low drying time
– Not so permanent as solvent ink

UV printers are appropriate for any application which involves the printing of a variety of substrates (also uncoated). The inks are cured and fixed with a special UV light. Both flexible roll materials and single sheets, but also rigid print media and even glass can be printed on. Appropriate protective measures are needed when processing harmful UV inks.

Printing widths: 137.2 cm to 500 cm

Principal use: Flat plate printing (rigid materials), textiles (roll printing)

+ Extremely durable (UV-resistant, water-resistant, scratch-resistant)
+ Suitable for outdoor use
+ Also on rigid and uncoated print media
+ No drying time
– Protective measures are required when handling (gloves, etc.), otherwise harmful to health
– Inherent odor of the inks

Water-based HP latex inks are still relatively new on the market. They are supposedly comparable with solvent inks in terms of quality and durability, but are less harmful to health and the environment. They do not contain real rubber, but consist of an aqueous polymer dispersion.

Printing widths: 51.4 to 264 cm

Principal use: Indoor and outdoor applications

+ Simple processing, no health risk
+ Suitable for outdoor use
+ Very to extremely durable
+ No drying time
– Limited choice of materials (because the ink must be fixed under heat)
– Only one printer manufacturer (HP)

Dye-sub printers work according to the thermal sublimation principle in which the water-based (and therefore non-toxic) ink is intensely heated and thus converted to a gaseous state abruptly (sublimation). The colour does not form a layer on the print material when applied, but bonds completely with the substrate. Textiles are thus lightfast and washable. Through-printing can be achieved on thin materials, which means that the image is visible on both sides.

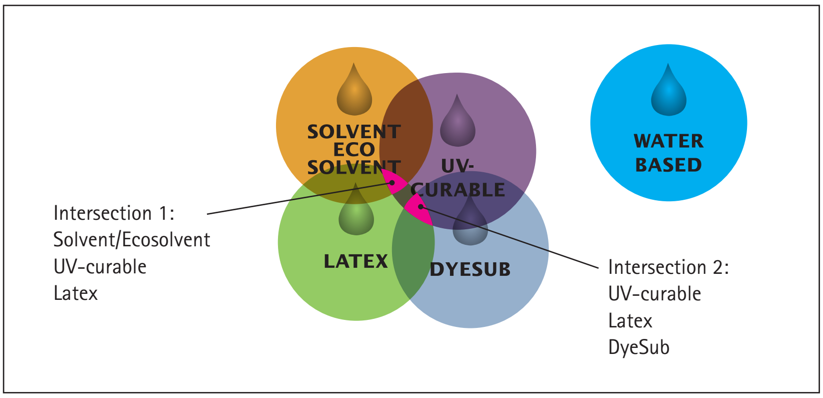
Printing widths: 137 cm to 320 cm

Principal use: Flags, textile banners, decor, fashion, interior design

+ Extremely durable
+ Suitable for outdoor use
+ High colour brilliance
+ Through-printing is possible (image is also visible on the reverse side)
+ The inks are not harmful to health
– Limited range of print media (textiles, polyester)
– Print media shrinkage during the printing process

Media compatibility:
Specific media currently exists for each ink system with two exceptions:
- For solvent/eco-solvent, UV-curable and latex ink systems, the same print media can be used in some cases (intersection 1).
- For latex, UV-curable and dye-sub ink systems, the same media range can be used in some cases (intersection 2)

Print service providers are therefore advised to carefully check for media compatibility or lack thereof.



2.7.3 Electrophotographic Printing (Xerography)

A very sophisticated overview can be found in the following reference: It is focused on OCE technologies but it provides a very good overview and technical insight into dry toner technology.

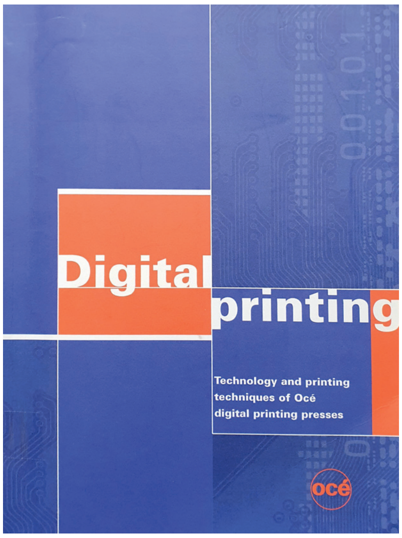


Fig. 2.22: Hoffmann-Falk, M., Digital Printing, Poing, 2005, ISBN: 3-00-001081-5

3 Basics for data preparation

3.1 Introduction

In times of conventional printing the responsibilities of data preparation were clearly addressed. The prepress department was responsible for the film creation (mostly 4 for CMYK) and the printing department was asked to transfer the halftones to the substrate in a reliable fashion. With the advent of digital printing those boundaries have been blurred. Print service providers often have to process data of unknown origin and quality. That mostly refers to rich PDF documents with objects (line work or raster) that are neither tagged with ICC source profiles nor separated for the actual printing conditions. In light of that situation print service providers are required to take responsibility for the preparation of the data. In order to allow for a defined level of predictability it should also be possible for the designer to visualize the final print product. Here the reference printing conditions come into play. These are ICC profiles (based on defined characterization data such as FOGRA51) which serve as interface for data creation and printing, see Fig. 3.1

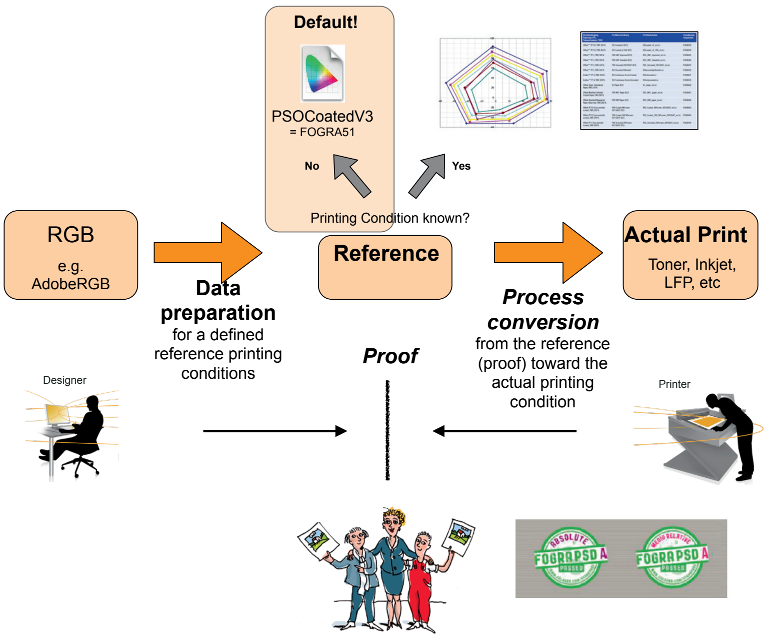


Fig. 3.1: Schema for determining the exchange space. The key question is the whether the actual printing condition, i.e. the used substrate and machine for the current job, is known. If this is the case, a reference printing condition resembling the actual printing condition is used. If no information about the actual printing is available it is recommended to use FOGRA51, i.e. PSO Coated V3.

Fig. 3.1 illustrates the print data workflow. The designer chooses from a set of exchange spaces (ICC profiles based on reference printing conditions). Based on print-ready PDF/X files reflecting the printing condition, a contract proof or a validation print can be created. This print serves both as a reference for the intended output preview and as the reference for the printer to rate the quality of the final print (with tolerance bands termed A, B or C). In case nothing is known about actual printing, it is recommended to use PSOCoated V3 as the default exchange space. The following sub-chapters are structured as follows:

- Overview of important reference printing conditions and exchange spaces.
- Designer guidelines for generating print-ready artwork (PDFXready Workflow V.2.4).
- Printer guidelines for optimized PDF handling.
- Migration from FOGRA39 to FOGRA51.

3.2 The Output-Intent: From printing conditions to exchange spaces

A printing condition is a set of primary process parameters which describe the conditions associated with a specific printed output, associated with colorimetrical and/or densitometrical aim values. For the purpose of colour management in digital printing application, a printing condition is fully characterized by giving the relationship between the CMYK digital input values (as stipulated in ISO 12642-2) and the corresponding measured colorimetric values. FOGRA51, for instance, is such a printing condition. While an offset printer might be interested in the associated process control information such as TVI-tables, black backing values or wet densities this information is not required for digital printing.

The following table shows the popular characterization data:

Update

Char.-file	Printing process	Profile file name	Substrate	Notes
FOGRA60	Metal decoration offset	Metal-Printing_MPC1_FOGRA60.icc	MC1, white coated	ISO 12647-9:2021
FOGRA59	Fogra Large Gamut Exchange Space	eciCMYK_v2.icc		replacs FOGRA53
FOGRA58	Fogra Large Gamut Exchange Space	TextileRGB_FOGRA58_beta1_.icc		
FOGRA57	Sheet fed offset + Glossy OPP	PSO_Coated_v3_Glossy_Laminate.icc	PS 1/2	based on FOGRA51
FOGRA56	Sheet fed offset + Matte OPP	PSO_Coated_v3_Matte_Laminate.icc	PS 1/2	based on FOGRA51
FOGRA55	Fogra ECG Exchange Space	Ref-ECG-CMYKOGV_FOGRA55_TAC300.icc		
FOGRA54	Web offset heatset	PSOsc-b_paper_v3_FOGRA54.icc	PS6 (super calendered, uncoated, SC-B)	
FOGRA53	Fogra Large Gamut Exchange Space	eciCMYK.icc	Premium Coated Universal	
FOGRA52	Sheet fed offset	PSOuncoated_v3_FOGRA52.icc	PS5 (OBA rich, uncoated)	* ISO 12647-2:2013
FOGRA51	Sheet fed offset	PSOcoated_v3.icc	PS1 = former PT1/2 (OBA rich, premium coated)	* ISO 12647-2:2013
FOGRA50	Sheet fed offset + Glossy OPP	PSO_Coated_v2_300_Glossy_laminate_eci.icc	PT1/2 (premium coated)	based on FOGRA39
FOGRA49	Sheet fed offset + Matt OPP	PSO_Coated_v2_300_Matte_laminate_eci.icc	PT1/2 (premium coated)	based on FOGRA39
FOGRA48	Web offset heatset	PSO_INP_Paper_eci.icc	INP (improved news print paper)	
FOGRA47	Sheet fed offset	PSO_Uncoated_ISO12647_eci.icc	PT4 (uncoated)	replaces FOGRA29
FOGRA46	Web offset heatset	PSO_LWC_Standard_eci.icc	PT3 (LWC web offset)	

Note:
All Fogra characterization data can be found: https://fogra.org/en/downloads/work-tools/characterisation-data

Char.-file	Printing process	Profile file name	Substrate	Notes
FOGRA45	Web offset heatset	PSO_LWC_ Improved_eci.icc	Improved LWC paper	replaces FOGRA28
FOGRA44	Sheet fed offset (non-periodic)	PSO_Uncoated_ NPscreen_ISO12647_eci. icc	PT4 (uncoated)	
FOGRA43	Sheet fed offset (non-periodic)	PSO_Coated_NPscreen_ ISO12647_eci.icc / PSO_Coated_300_ NPscreen_ISO12647_eci. icc	PT1/2 (premium coated)	
FOGRA42	Web offset heatset	PSO_SNP_paper_eci.icc	Standard news printing paper	
FOGRA41	Web offset heatset	PSO_MFC_paper_ eci.icc	MFC (machine finished coated)	
FOGRA40	Web offset heatset	SC_paper_eci.icc	SC (super caland-ered)	
FOGRA39	Sheet fed offset	ISOcoated_v2_eci.icc / ISOcoated_v2_300_eci. icc	PT1/2 (premium coated)	replaces FOGRA27

Tab. 3.1: Overview over the Fogra characterization datasets.

However, since offset printing conditions represent the majority of standardized commercial printing, they serve as legacy data and may be used as reference printing condition also for digital printing applications.
This situation has changed with the advent of the first colour exchange space FOGRA53 (eciCMYK).

CMYK-based colour exchange space: FOGRA59 (eciCMYK_v2)

FOGRA59 is a CMYK-based exchange space that primarily serves colour communication throughout the print production. FOGRA59 allows for a consistent colour reproduction throughout production including copy preparation, job assembly, proofing, and process colour printing.
FOGRA59 fullfils the following three essential requirements:

- It spans the expected range of colour gamuts used for the production of printed material from digital data, regardless of printing process used.
- It allows proofability on the established proof printers and hence an objective colour reference.
- It resembles established CMYK-based printing gamuts in size, shape and tonality.

Hint:
For more informations see: https://fogra.org/en/research/prepress-technology/consolidating-standardization-10057

In order to be able to create and exchange print data in a standardized way, dedicated colour exchange spaces are the right tool at hand. By using them, the expected print result should be rendered accurately and precisely and neither too “beautiful” nor too “washed out”, thus limited in gamut and dynamic range.
The advantage of using a CMYK-based exchange colour space is that the complete design takes place in a single colour space. Colour communication with the client is based on the approval of one single contract – in contrast to the preparation of dedicated CMYK separations and corresponding proofs. Starting from FOGRA59 colour-managed and approved artwork, print data will be converted into the pertinent printing conditions.
The two de-facto standards FOGRA39 (ISO Coated v2) and increasingly FOGRA51 (PSO

Coated v3) found their way into conventional offset printing – and beyond – as exchange colour spaces. However, it often remains unclear to what extent the used colour space was intended as an absolute preview of an actual production printing condition or a relative reference (as usually used in lieu of an exchange colour space). Furthermore digital printing applications increasingly require larger exchange spaces in order to make the best use of the device capabilities.

Together with FOGRA59, ECI released the corresponding ICC profile named „eciCMYK_v2.icc" for download free of charge on the ECI website (http://www.eci.org/de/downloads).

Please use both mailing lists for discussions in regards to FOGRA59 and eciCMYK_v2: ECI (http://www.eci.org/de/mailinglists) as well as the Fogra Digital Printing Working Group, DPWG (http://lists.fogra.org/listinfo/dpwg). The characterization data can be found on the Fogra website, as always.

The PDF/X-ready Output intent rules

Any PDF/X-file is characterized by a so called Output-Intent, that defines which printing conditions the document is prepared and therefore intended for. Print elements may be exchanged either as output device code values or as colorimetrically defined data. However, both types of data, if present in print elements in a PDF/X file, shall be prepared for the single characterized printing condition identified in the output intent prior to exchange. The Output-Intent allows e.g. the newspaper printer to identify if the print elements have been prepared correctly. It should be noted that the Output-Intent does not trigger any colour transformation; it only characterize the available objects in an unambiguous fashion. In contrast device dependent colour definitions often lead to proprietary, automatic transformations

With respect to the correct interpretation of the Output-Intent there are two different points. On the one hand it is important to know that different ICC-profiles are attributed to the same characterization data-set. For instance the output profiles ISOCoated V2, ISO Coated V2 300, ISOCoated V2 (BAS) and CoatedFOGRA39 are all based on FOGRA39. That means that they are identical with regard to the CMYK to CIELAB transformations but different in regard to CIELAB to CMYK transformation namely the Gamut-Mapping as well as the black generation – including the maximum tone value sum (TVS), also known as total area coverage (TAC). Image data that is prepared (separated) with different ICC profiles, which are all based on the same characterization data-set, can be problematic when it is collectively imposed on a large sheet. Those problems refer mostly to offset printing when printers see different „reactions" within the image (ranging from no change to huge changes) when they change the inking of one printing ink.

On the other hand problems arise when Output-Intents are used that resemble completely different output processes, i.e. printing conditions. Here it is extremely important to identify these cases in order to take corrective actions. The PDFXready-rules, part of the PDF/Xready preflight profiles, are carefully designed to address both problems. The following pages summarize the most important information. If not defined otherwise, Fogra recommends the usage of the ICC profiles provided by the ECI (www.eci.org).

Sheet-Fed Offset on coated and uncoated stock (selection)

- PSOcoated_v3.icc
- PSOuncoated_v3_FOGRA52.icc
- ISOcoated_v2_eci.icc
- ISOcoated_v2_eci_300.icc
- PSO Uncoated ISO12647 (ECI)
- ISOuncoatedyellowish.icc
- PSO_Coated_300_NPscreen_ISO12647_eci.icc
- PSO_Coated_NPscreen_ISO12647_eci.icc
- PSO_Uncoated_NPscreen_ISO12647_eci.icc

More profiles can be found in the 2020 PDFXready guideline.

ICC-profiles not mentioned here

An unknown ICC-profile being used in the Output Intent is an indication for either an erroneous PDF creation or an individual printing condition. In any case check the delivered data. Additional communication between provider and receiver is recommended.

Note:

Formally there are no ICC-profiles from ISO. Based on concerns and subsequent discussions within some standard groups ECI decided not to use the term „ISO" anymore. The acronym "PSO" was used instead in combination with information about the used substrate and screening. For digital printing the process parameters are less important but provides guidedance for the gamut check with the intended output process.

Update

CMYKOGV-based colour exchange space: FOGRA55

FOGRA55 is a CMYKOGV-based, process-agnostic ECG exchange color space, developed as part of the Fogra research project 13.003. This exchange colour space is intended to serve as an intermediate colour reference for colour communication involving CMYKOGV-like-systems before the actual digital printer is selected. The ICC profiled is created based on the characterization data FOGRA55 that reflects gamut of typical ECG systems to achieve a good usability actual production as well as a good proofability. To ensure consistent colour reproduction of established CMYK-based data sets such as ISO 12647-2:2014, the CMYK part and the white point of FOGRA55 are designed to match those of FOGRA51. See also chapter 3.7 for more information.

Note:

The characterization data as well as the corresponding ICC-pofile 'Ref-ECG-CMYKOGV_FOGRA55_TAC300.icc ' is available free of charge on the Fogra website (https://fogra.org/en/downloads/work-tools/characterisation-data).

Summary

A central piece of PDF/X is the Output Intent. It characterizes the intended printing condition and allows for an easy identification of the creators intent.

In general the usage of the profiles provided by the ECI (European Color Initiative) namely ISO Coated v2 300%, PSO Uncoated ISO 12647 (ECI), PSO LWC Improved (ECI) and ISO Newspaper 26v4 provided by WAN-IFRA is recommended. Other profiles will result in preflight messages and indicate potential problems while creating or repurposing the data.

The mentioned PDFX-ready rules helps to identify the correct Output Intent and how to check if a supplied profile can be used or not. However it is not clear how a print service provider should react when receiving inappropriate Output Intent. That is part of the following sections.

3.3 Designer guidelines for generating print-ready artwork (PDFXready Workflow V2.6)

The following pages cover guidelines both for designer and prepress companies (termed "Creator") as well as the print service providers (termed "Output"). In particular the latter has to deal with data that is not adequately prepared for printing. These pages help to deal with that situation.

Hint:
As of V2.5 PDF/X-ready is not maintaining the tools (colour management settings, preflight settings, cooking receipts). Since the differences between version 2.5 and 2.6 are marginally, the use of 2.5 is recommended for the time being.

PDF-Processing – Yesterday, today and tomorrow

As the printing and publishing industry has changed so has the way PDF files are handled. The multichannel publishing paradigm is replacing the conventional way of data preparation designated for a specific printing condition. This evolution is evident in changing publishing processes that strive for media neutrality, making cross media data preparation essential.
Over the last decade PDF has become the standard file format for prepress workflows. The PDFX-ready V2 Workflow guideline no longer relies on PostScript, but instead utilizes the native PDF rendering capabilities of current prepress RIPs. By utilizing native handling of PDF objects, significant benefits can be gained that are not possible with PostScript. Many of these benefits will be described in this guideline.
PDFX-ready RGB V2 represents the first time a set of provisions that allows for media neutral RGB-data. However this is currently restricted to pixel based data, also known as raster. Technical tones and vector graphics (also known as linework) must still be prepared and placed by means of appropriate CMYK tone values. A true media neutral document description is not yet achieved, since the linework must be prepared for each individual printing condition. Therefore PDFX-ready RGB V2 is a proposal for the industry to start with the media neutral paradigm. Media neutral image storage and archiving is now standard practice for the much of the industry. PDFX-ready V2 recommends clearly to utilize this practice in a controlled fashion without separating raster images for a set of printing conditions. Future versions of PDFX-ready will explore the concept of media neutral documents instead of just media neutral images. Modern output channels such as tablets require that both vector and raster data is represented in RGB, requiring the need for media neutral documents. PDFX-ready V2.4 settings are still based on ISOcoatedV2 as the exchange space.
With introduction of profile version 2.5 the colour management settings are available for both ISO Coated v2 and PSO Coated v3.

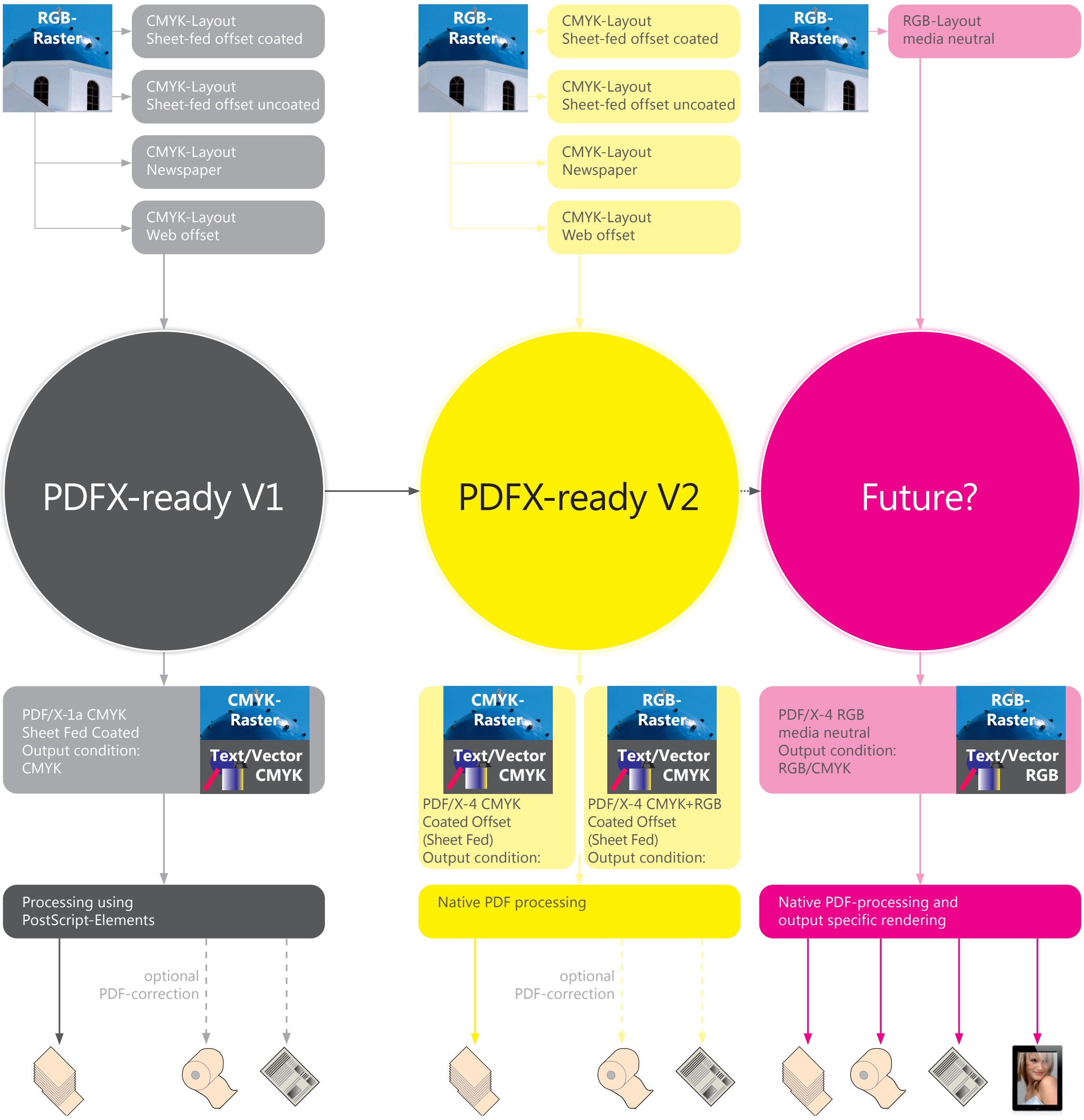


Fig. 3.2: Overview of the different types of guidelines, which covers the pertinent technologies and approaches. Summarized as: Yesterday (PDFX-ready 1.3), Today (PDFX-ready V2 CMYK) and Tomorrow (???).

Workflow-Overview

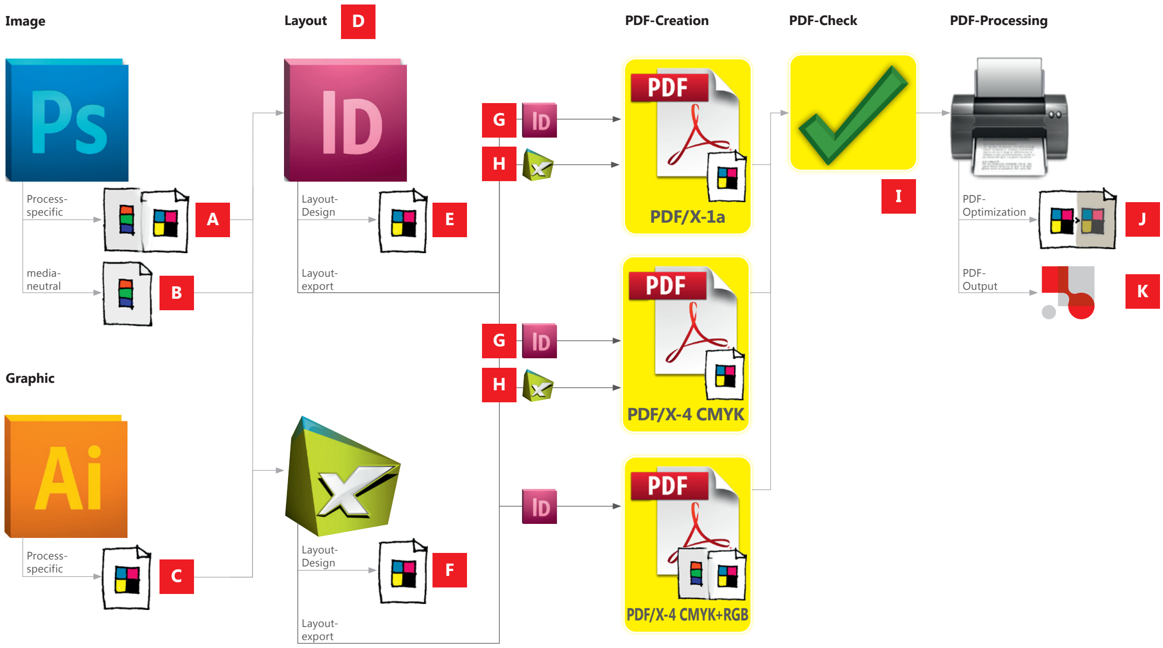


Fig. 3.3: Overview of the different steps of the production chain. PDF/X-4-CMYK+RGB is currently subject for field testing and not recommended for default usage.

This overview shows different steps along the production chain by illustrating typical ways of PDF/X-workflows:

¬ Image Retouching – media-neutral or process specific
¬ Graphic creation – process specific
¬ Layout creation – media-neutral or process specific
¬ Layout export – process specific or media neutral PDF-creation
¬ PDF/X-Files using the «flavours» PDF/X-1a, PDF/X-4 CMYK and PDF/X-4 RGB
¬ PDF-Check
¬ PDF-Optimization and output

More information can be found on the given sections (A, B, C etc).

Colour Management

The term «Binding» is related to the stage in the workflow where the data conversion (e.g. RGB -> CMYK) towards the intended printing condition happens. With respect to the typical graphic arts workflow there are 3 possible stages for binding:

¬ Early Binding
¬ Intermediate Binding
¬ Late Binding

The following guidelines are specific to pixel based images (i.e. raster data) because usually only pixel images are converted from RGB to CMYK.

Early Binding

Raster images are converted to CMYK in an image editing software such as Adobe Photoshop. The user has full control of the conversion. This is generally determined by the destination profile, the rendering intent and black point compensation.

Intermediate Binding

The images are retouched and remain unseparated (media neutral), e.g. by using the RGB-format. These RGB-images are then placed in a layout. When a print quality PDF is exported, all images are converted to the output condition. The user controls the conversion by means of the basic application settings, document colour settings, as well as the PDF export settings used.

Late Binding

RGB images are exported into the PDF including the embedded source profile. The conversion to the destination colour space is only done during output using the colour management settings of the output workflow.

Media neutral data preparation with PDF/X – a contradiction?

Both PDFX-ready V1.3 and V2 CMYK workflows are designated as process specific ways of data exchange. This is because the content is already fully prepared for the output intent. The PDF document only contains print elements encoded as CMYK, gray or spot colour. This means the RGB images are either converted to CMYK at the PDF export from the layout application (Intermediate Binding) or are already availabel in the CMYK of the output intent (Early Binding).
To convert images already in the image edition software is considered to be the most conservative approach. Although you have full control of the separation, you will need different images for each individual printing condition

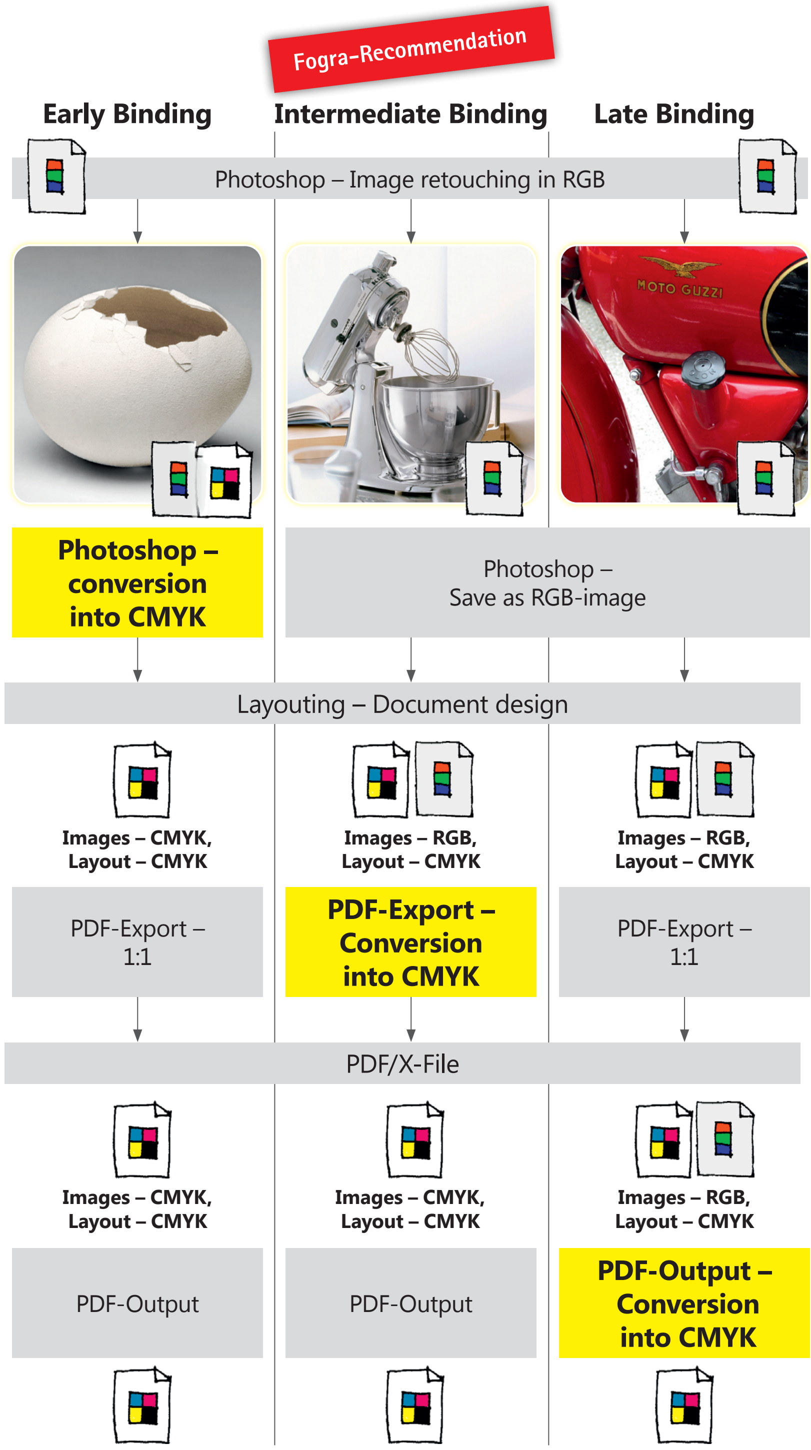
In most cases you can use these default settings for the conversion to CMYK:
- Relative colourimetric rendering intent (optional use of blackpoint compensation)
- Embed the source (RGB-) profile
- Make sure the right destination profile is selected or used by default

Fogra recommends to use Intermediate Binding. By going that way you can use one image file that serves as a master. This helps to reduce errors in particular those related to picking the wrong version of an image.

Early Binding should be used when:
- Corrections (Retouching) is required in CMYK
- Conversion must be done with different settings
- A destination profile is used that performs a dedicated black generation or separation in general while reflecting the same underlying printing condition. That is typically the case for Microsoft excel charts or textile reproductions.

When using Intermediate Binding care must be taken to apply the correct colour settings, document colour settings and PDF export settings.
Intermediate Binding has the advantage that RGB images will always be converted to the correct output profile. In addition there is no need to store and maintain multiple versions

of images for diffrent won't be any need to hold and maintain different output conditions. Using intermediate binding allows for changing of the output intent at the PDF creation stage when needed. However, keep in mind that linework must be re-separated since it is prepared for one specific printing condition. See also chapter 3.4 for more information on setting up a colour server to do so.



PDFX-ready Example Page

The PDFX-ready test page as shown below is your guardian angel for this PDFX-ready Guideline. It shows the advantages of the PDFX-ready-Workflows V2.

Fig. 3.4: Visualization of the PDF/X-ready V2 Example page. It is a helpful tool for testing the your workflow. Please download it from the PDFX-ready or the Fogra homepage. This test page does not replace the PDFX-ready certification. It also won't replace test pages provided from other organizations. It is an additional tool for testing and demonstration.

Hint:
You can download the example page at the PDFX-ready homepage. Detailed information about the individual patches can be found at the following pages.

You can use the test page to:

- review the benefits related to the usage of the PDFX-ready-guidelines.
- make notes about the fundamental parts of PDF creation and processing.
- check your workflow by means of seeing how subtle details of this file might be rendered at your output system.

This guide uses the following symbols:


The check mark indicates that a result is OK.


The red «X» shows an error or a significant problem that leads to problems.


Warnings are depicted by the yellow acclamation mark. These depend on you and your individual situation.


Information is marked by the blue «i». It represents additional provisions and guidance.

3.3.1 Which PDFX-workflow to pick?

PDFX-ready offers two different workflows: V1 and V2. Since V1 is based on the «classic» PDF/X-1a approach, V2 uses PDF/X-4 and therefore allows means for state of the art PDF creation and processing including life transparency and media neutral artwork.
The PDFX-ready-Workflows are guidelines for checking PDF documents. Although PDFX-ready provides settings and recommendations for the creation of layouts (InDesign, QuarkXPress), there are always many ways that lead to a "good" PDF. What counts is the quality of the final PDF against the PDFX-ready-Preflight rules.
What is characteristic of the PDFX-ready-Workflows and how do you pick the right one? It depends on the level of sophistication and equipment of your print service provider, also known as output partner.

What is flattening?
Imagine a complex composition of graphics and vectors and images including smooth shades, drop shadows and fancy blend modes. Flattening means achieving the same visual appearance by using Quark 4.

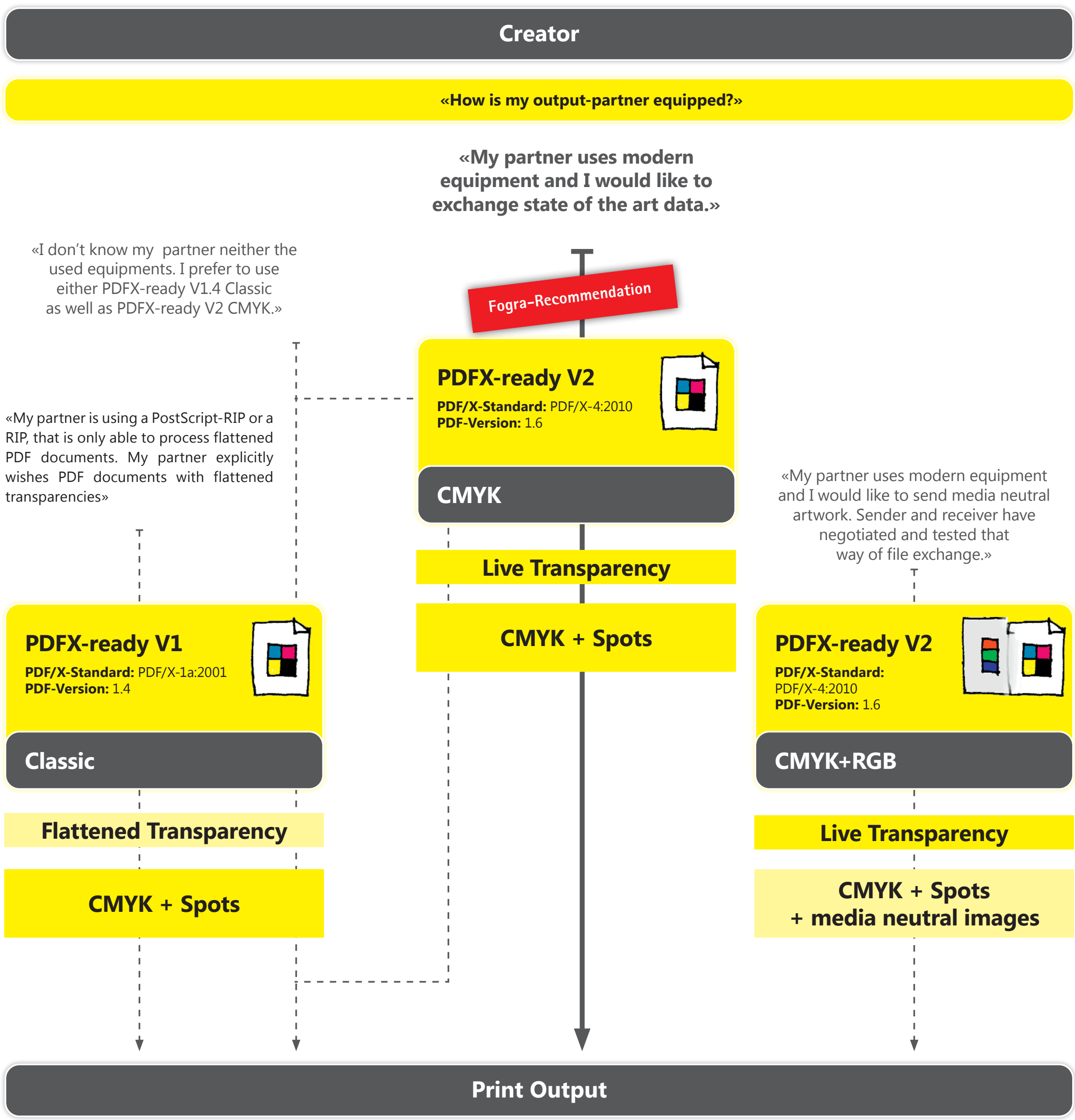


Fig. 3.5: Three PDF/X-ready workflows. Using „PDF/X-ready V.2 CMYK+RGB" requires a high level of sophistication of all parties. In practice, the use of CMYK + RGB does not have any notable advantages over CMYK. It is therefore not recommended.

Why PDFX-ready V2?

The PDFX-ready V2-settings reflect the PDF/X-4-standard and the PDF/X-Plus-specification prepared by the Ghent Workgroup (GWG). They have been extensively revised in order to reflect state of the art needs of current PDF workflows. What are the key aspects of PDFX-ready V2 and why should you update?

Live-Transparency

When using PDFX-ready V2, live transparency does not need to be flattened. Live transparencies are explicitly allowed in PDFX-ready V2. This leads to a number of advantages when creating and processing PDF documents:

- PDF-creation is faster and more reliable, since there is no flattening process.
- The resulting PDF documents have a smaller file size, since the flatting process often ends with complex compositions of (opaque) objects.
- Increasing quality of the PDF files by means of:
    - Preserved text (which often will be converted to paths (outlines) or into raster images).
    - Gradients will be encoded natively as smooth shades instead of images or older mechanisms.
    - Vector objects will be preserved as vector and not (as it is sometimes the case) raster.
    - Artefacts (e. g. fine white lines), that might result from the flattening process can be avoided.
- The rendering of the PDF document will be enhanced: There are no visualization errors anymore such as fine lines that disappear when zooming in. This is also important when creating interactive PDFs, which are used for screen viewing (Internet, tablets or e-readers), since not all PDFs are destined for print.
- PDF files can be edited more easily, since the objects appear in the same way they are layouted and composed (in contrast to being split into many pieces).
- PDF files can be more easily converted to different output conditions. In addition spot colours can be fixed if the transparency is live. Once flattened, spot colours involved in transparency cannot be altered.

Archivability

PDF documents that comply with PDF/X4 basically comply with PDF/A-2. PDF/A-2 is a standard for long-term archiving. Using PDFX-ready V2 allows you to prepare data that is "future-oriented" by means of the requirements of tomorrows digital archives.

Stringent Font-embedding

PDF/X-4 defines more stringent rules for embedding fonts and single characters and glyphs. This helps to reduce potential problems when processing PDFs, for instance at the imposition stage.

Layers in PDF

PDF/X-4 allows for layers. These optical content groups permit the dissemination of multi-language PDF documents as well as non-printing content such as die-cutting.

16 Bit

Using PDF/X-4 you can save image data encoded with 16-Bit. A bit-depth of 16 (per channel) allows for a higher accuracy of colour values and the following transformations. However in order to benefit from a 16-Bit workflow all parts must work together. It is still common to use a 8-Bit encoding (255 different tone levels). It must be said the a unified 16-Bit workflow system is not realistic in the near future since many programs struggle to fully support it.

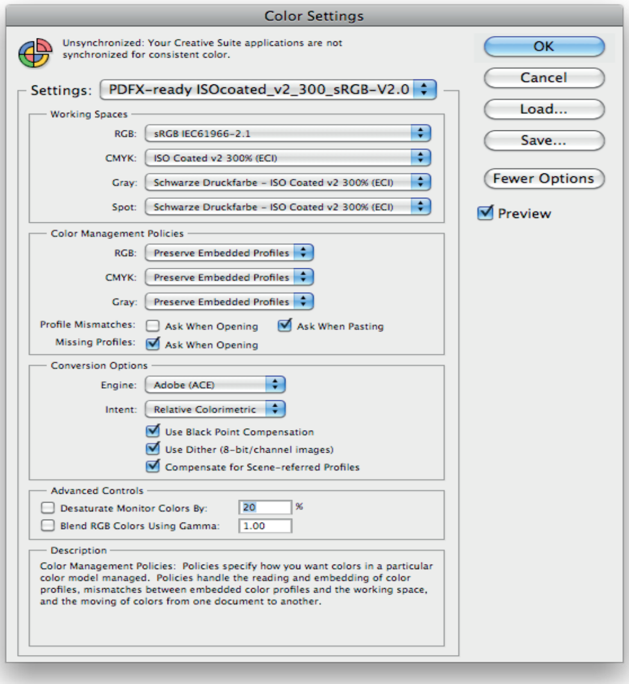
JPEG2000-Compression

PDF/X-4 allows image data to be saved in the JPEG2000 format. With the use of JPEG2000 compression, the amount of data can be reduced, but longer export and output times must be expected. Comparable to 16-Bit handling, many programs and authoring tools have problems fully supporting JPEG2000 encoding image data. In case this is foreseeable, it is advised to use PDFX-ready V1, which disallows JPEG2000 and therefore uses alternative compression techniques.

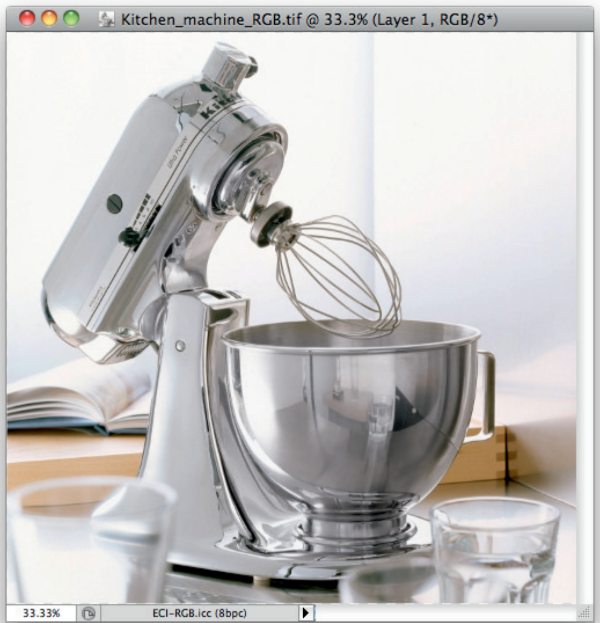
Recipe
A
Simply Rip out

Process specific image preparation

1. PDFX-ready provides Photoshop colour settings. You can download the csf-files at www.pdfx-ready.ch. You can also use these files to synchronize the colour settings all CS applications by using Adobe Bridge.

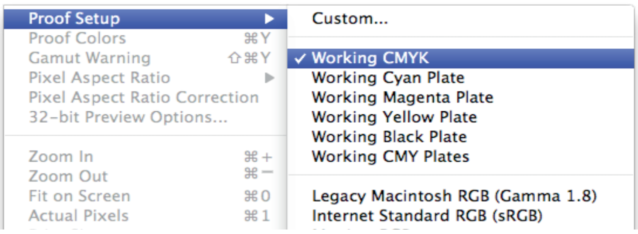


2. In order to prepare images for a specific printing condition it is recommended to do the retouching in RGB.

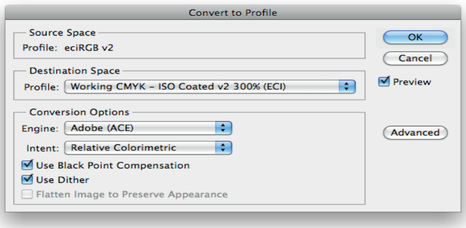


3. The final appearance can be visualized by using the softproof (Proof Setup) of Photo-

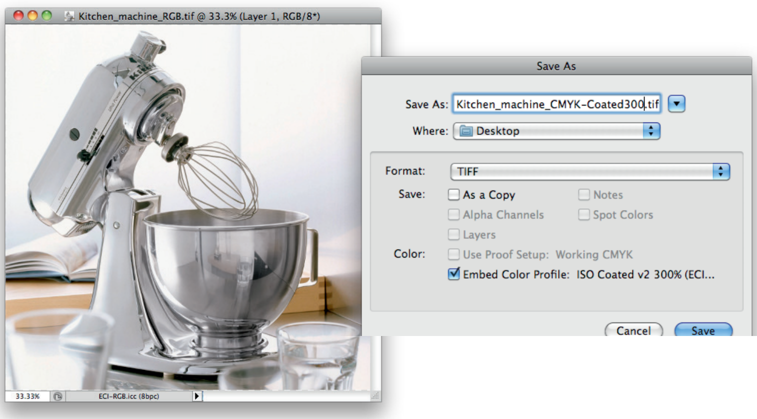
shop. Simply go to View -> Proof Setup -> CMYK-Working Space for the selected output condition or Custom for individual settings. Then there are no nasty surprises after the conversion.



4. After finishing the retouching the conversion to CMYK can be applied there. Please use Edit -> Convert to Profile in order to find the best settings. This step is not standardized. While the recommend ICC profiles often result in satisfactory separations different profiles (representing the same printing condition) might also be used.



5. Save the final CMYK-image by using one of the typical file formats (TIFF, PSD or JPG). Please note to include the used ICC profile when saving the image file. When preparing images in a process specific way each printing condition require a separate image that has been prepared for the pertinent process. It is recommended to store the original RGB-file as the basis for additional separations. If you have to prepare data for different output processes this method result in a lot of redundancy including a higher risk for potential errors. A more flexible solution is to let the layout application do the RGB-CMYK-conversion. (see page 24) or a tailored CMYK-CMYK-Devicelink transformation (Section J).

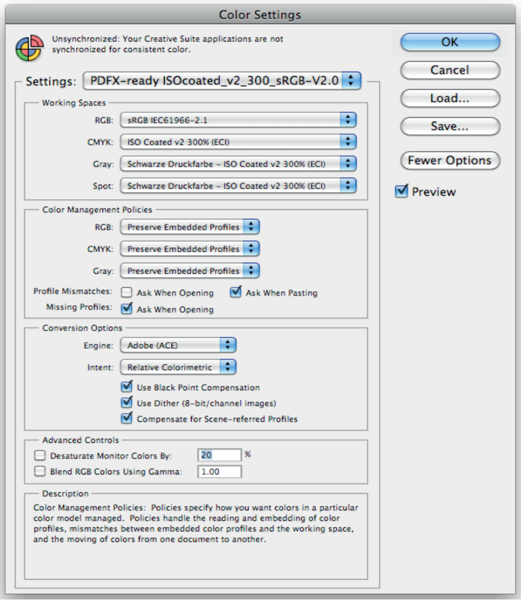


Recipe
B
Simply Rip out

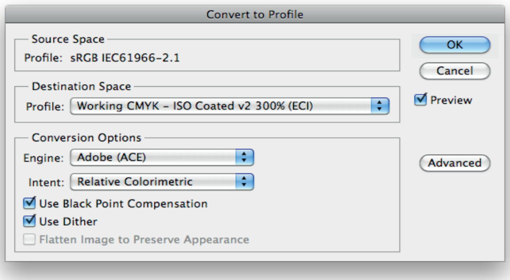
Media neutral image preparation

This recommendation is based on a media relative conversion with black point compensation (bpc) throughout the workflow.

1. PDFX-ready provides Photoshop colour settings. You can download the csf-files at www.pdfx-ready.ch. You can also use these files to synchronize the colour settings all CS applications by using Adobe Bridge.



2. In most situations it is recommend to convert all RGB colour space to a well defined working space. PDFX-ready recommends the eciRGBv2 working space. Please select Edit -> Convert to Profile, to do the conversion as shown.



Hint:

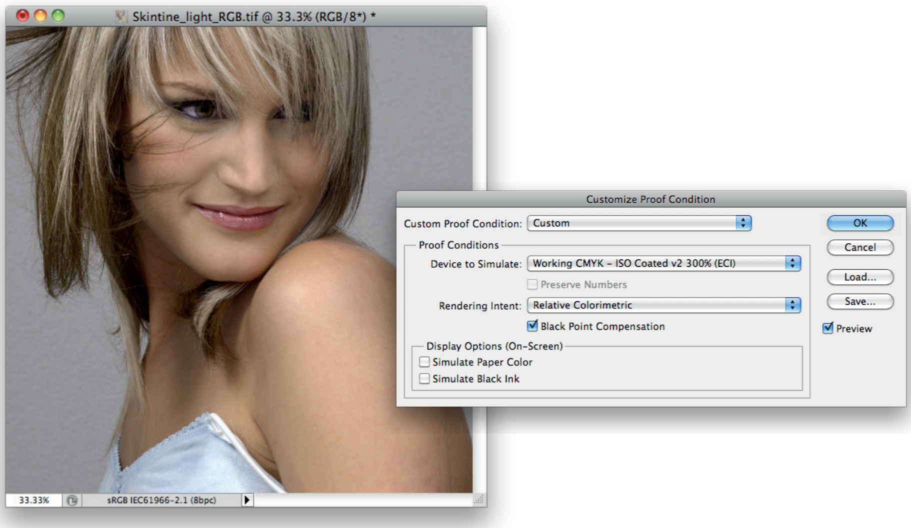
For Media with high amount of Optical Brighteners Agent (OBA) the perceptual Rendering Intent mostly provide better result. For more Informations see: https://fogra.org/en/research/detail/research-day-307

Black Point Compensation (BPC)

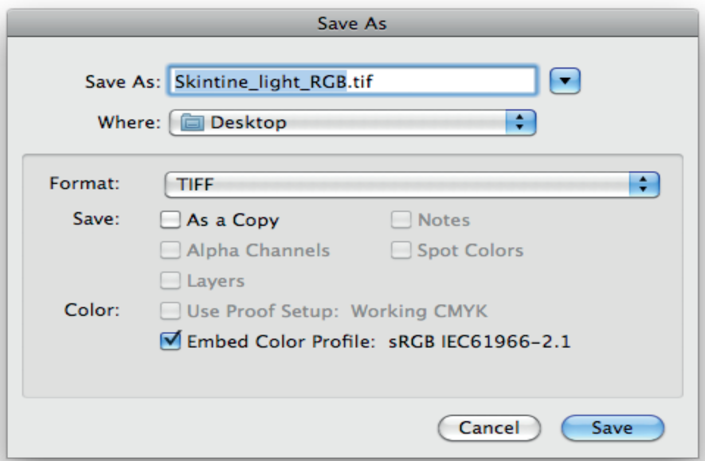
In addition to the “relative colorimetrical” rendering intent, black point compensation allows for better shadow details. For the perceptual rendering intent, bpc has (mostly) no effect.

Background: Black point compensation is a method developed by Adobe and is available in Adobe applications. As a result of the publication of ISO 18619, it can be expected that the differences in the BPC between the application programs become smaller.

3. The retouching should be done on a calibrated and profiled monitor, in RGB colour space. In case a specific printing condition is on your radar you can activate the softproof preview by clicking View -> Proof Setup -> Custom. This allows you to preview how critical (e.g. saturated) colours will be later separated. PDFX-ready recommends to use the CMYK working space "ISO Coated V2 300% (ECI)".



4. Save the final RGB-file by using one of the typical file formats (TIFF, PSD or JPG). Please note to include the RGB profile. This image now serves as a master both for print (offset printing on coated or uncoated art, newspaper printing etc) and non-print (e.g. Web, Tablet) output conditions. This media neutral archiving founds the basis for future multi-channel publishing workflows. The needed conversion to the intended CMYK-colour space is done either by the Layout application (G, H) or by the PDF-colour server to be used by the sender or receiver (J, K).



Recipe
C
Simply Rip out

Process specific preparation of graphics

1. PDFX-ready provides Illustrator colour settings. You can download the csf-files at www.pdfx-ready.ch. You can also use these files to synchronize the colour settings of all CS applications by using Adobe Bridge.

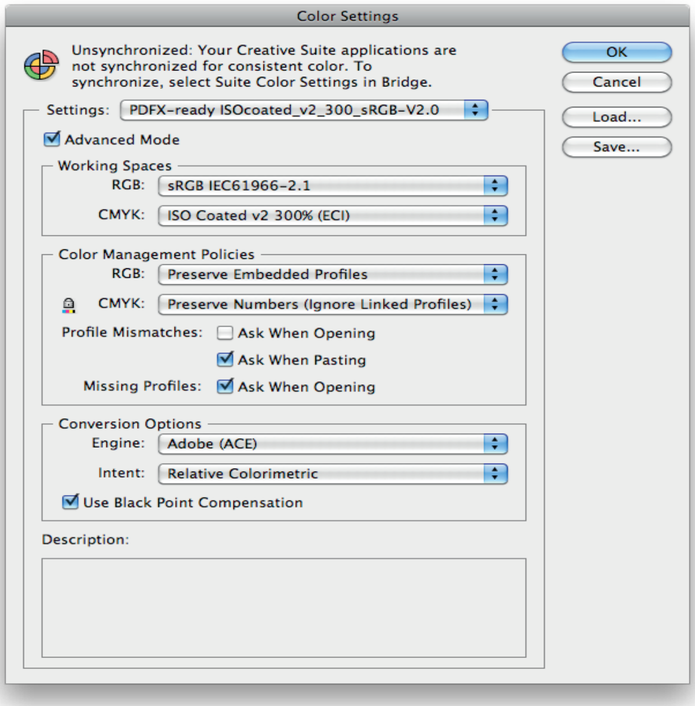


Fig. 3.6: Recommended colour settings.

2. Prepare the linework in Adobe Illustrator by using the CMYK working space. Using the following logo graphics you will find some useful hints to do prepare the vector data correctly.

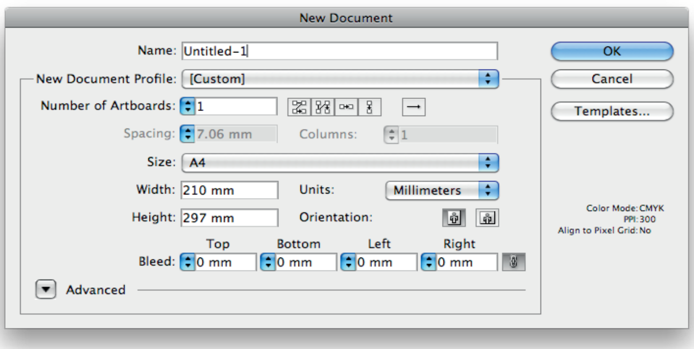
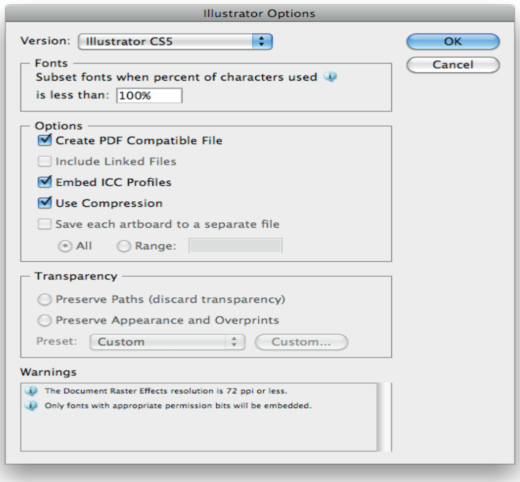


Fig. 3.7: Recommended colour settings.

3. Save the graphic by using the AI-format. Please try to avoid EPS-files, since they don't support live transparencies.



Overprint Preview

InDesign, Illustrator and Acrobat offer a so called "overprint preview". It allows you to visualize the effect when the present overprint settings will be honored. Please select: View -> Overprint Preview

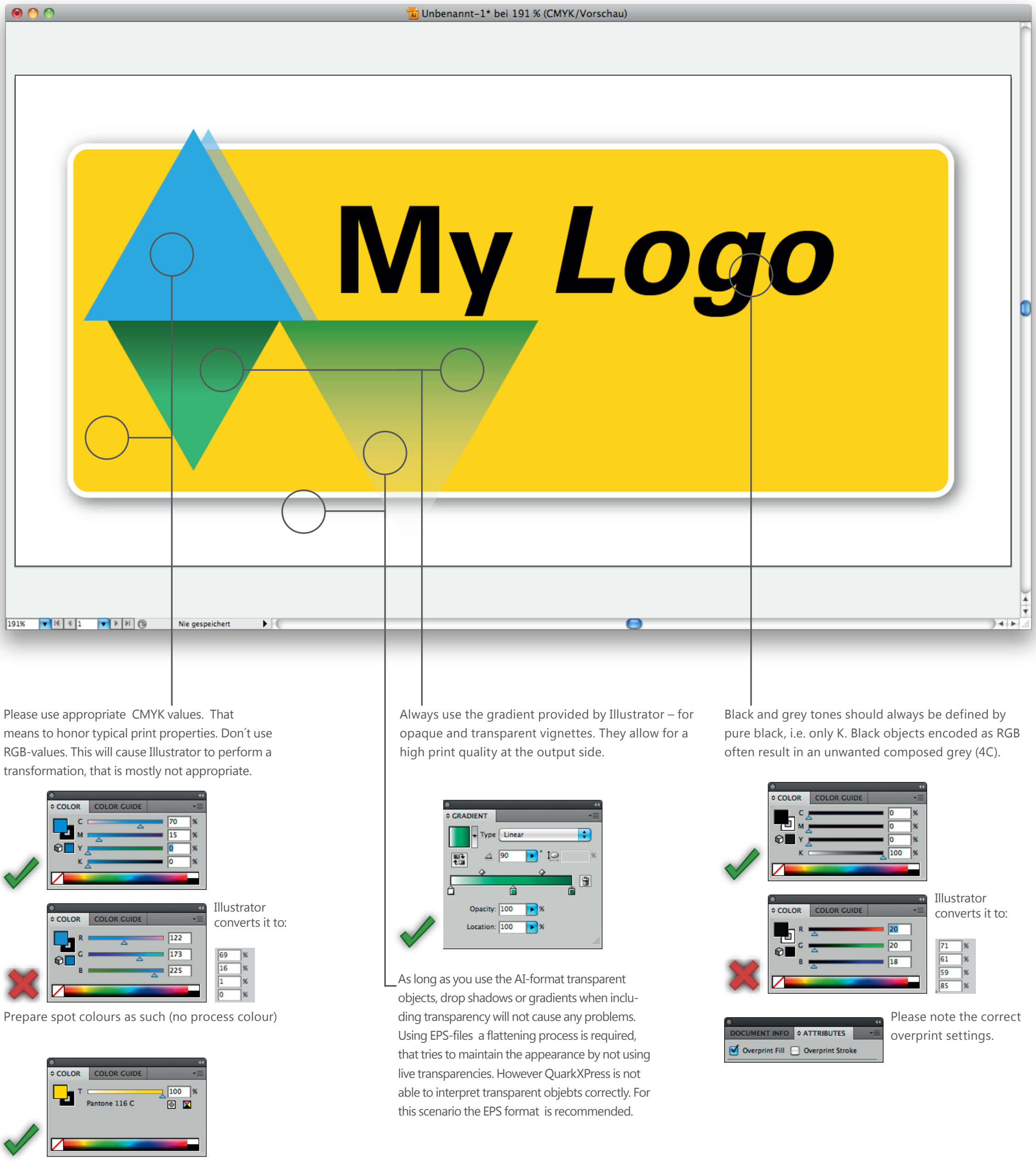


Fig. 3.8: Hints for the practical preparation of graphics also known as technical tones by means of the program Adobe Illustrator.

Configurating layout applications – New documents

Using images with tagged ICC profiles is not new, but it is not common knowledge that this mechanism is also provided by layout documents. Modern layout programs require two profiles: one for CMYK and one for RGB objects. Both profiles will be used for newly created documents. They are defined in the basic colour settings. But what are the implications for a CMYK-based print workflow?

¬ The RGB-profile will always be employed when RGB-objects without an attached profile are used (DeviceRGB). That scenario should not be used by professionals therefore it can be ignored.

¬ The CMYK-profile defines the source and destination colour space for all placed CMYK elements (DeviceCMYK), assuming the PDFX-ready settings are in place (see bottom). The InDesign settings are depicted below while the QuarkXPress settings can be found on the next page. This requires that all imported CMYK elements (both linework and artwork) must be prepared for the intended printing condition represented by the CMYK-profile. CMYK objects with tagged profiles will be handled according to the PDFX-specs as DeviceCMYK. Images prepared for different printing conditions must be converted to the intended printing condition before placing them in the layout. By doing this, unwanted CMYK-CMYK transformations can be avoided.

The PDFX-ready-export settings for InDesign honour the document profiles. That allows for a generic PDF-export setting for all kind of output conditions since the destination profile (Output Intent) will be defined by the document colour space. In case of CMYK-based output all RGB-based elements will be converted to CMYK. Combining the document with the export settings underlines the importance of consistent colour handling of both artwork and linework.

In QuarkXPress offers no link between the document setup and the PDF export. That's why it is extremely important to select the PDF output style that fits to the present document setup as well as the prepared data being used.

PDF/X-Output Intent

Any PDF/X-file contains a so called output intent. It indicates for which printing condition the objects within the document have been prepared for. The Output Intent must be selected when creating the PDF-file.

Recipe
E
Simply Rip out

InDesign as of CS4

PDFX-ready provides InDesign colour settings. You can download the csf-files at www.pdfx-ready.ch. You can also use these files to synchronize the colour settings all CS applications by using Adobe Bridge.
These colour settings represent the basic settings for all new documents.

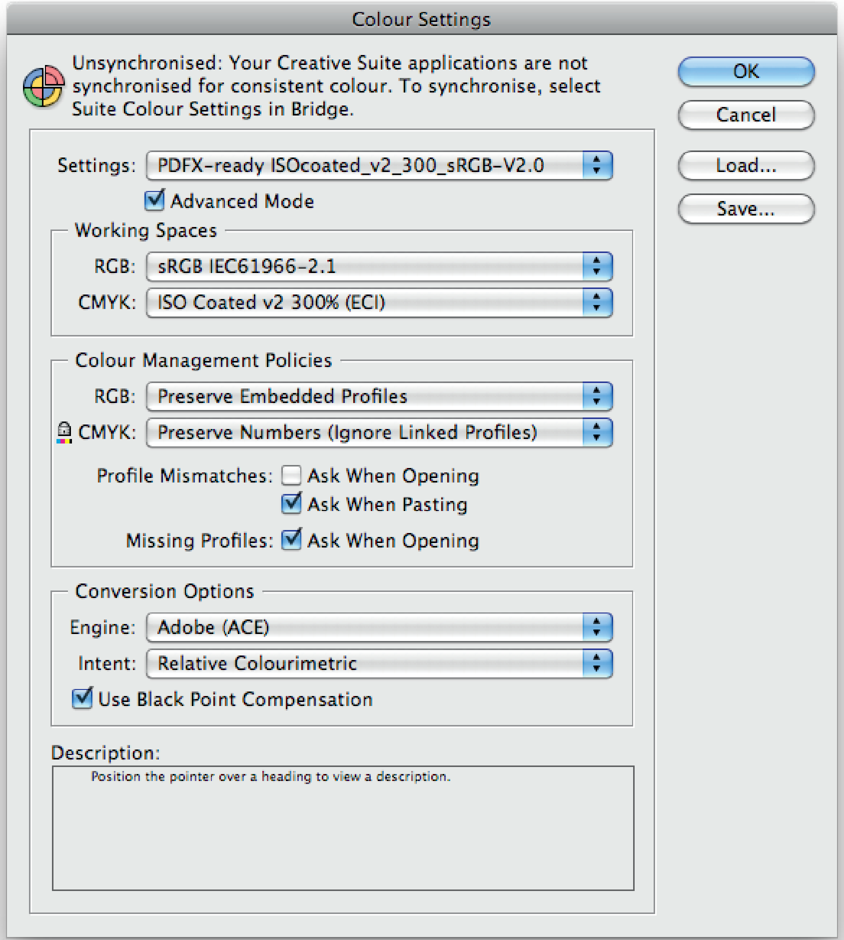


Fig. 3.9: Recommended Colour Settings

Recipe
F
Simply Rip out

QuarkXPress as of version 9

PDFX-ready provides source setups for QuarkXPress as of version 9 . You can download the files at www.pdfx-ready.ch. Those settings will be imported by means of a «mother document» after which they should be applied in the source setup window. Details can be found at the PDFX-ready webpage.
Based on the source setup the basic colour settings will be defined. They form the basis for all new documents both for RGB- and CMYK-elements

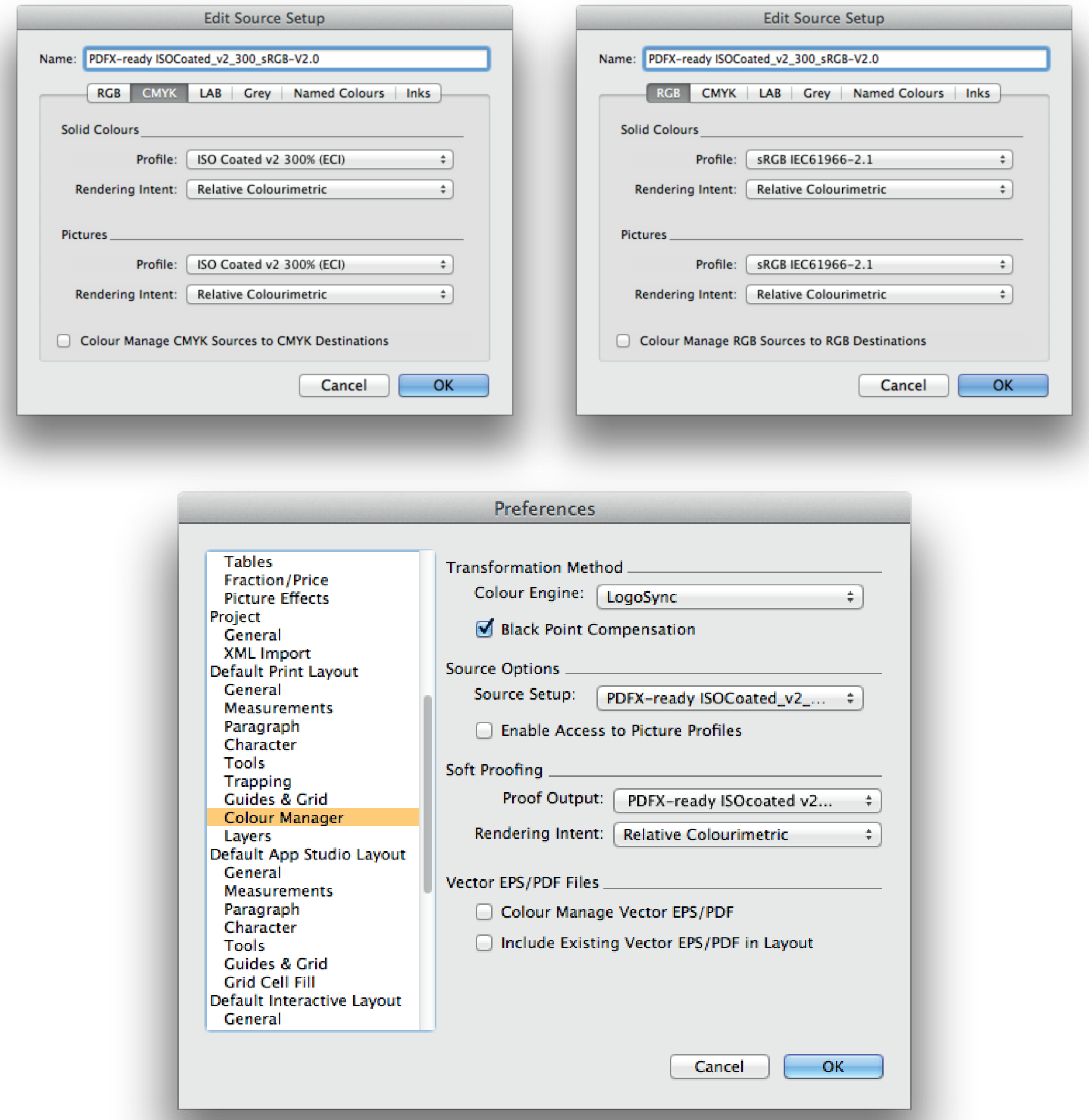


Fig. 3.10: Recommended Colour Settings

Configuration layout application – Old documents

For new documents the basic colour settings are used (assuming the usage of the PDFX-ready settings), so you don't have to bother about them. However, for old or existing documents other rules apply. Here the profiles stored within the document will be used. In order to fix them a manual correction towards the PDFX-ready settings is needed.

InDesign as of CS4

Open the existing document and click on Edit -> "Assign Profiles...". Here you have to change the RGB and the CMYK profiles to the PDFX-ready working spaces. This leads to an adjustment of the document colour settings. Regardless, you have to take care that the present elements are indeed representing the newly assigned profiles or printing conditions, otherwise errors are unavoidable. This step is particularly important when using InDesign since the document CMYK-colour space (working space) will be used for the PDF export. A print ready PDF file therefore relies on the consistent usage of imported graphics and images that fit to the selected output condition (Output Intent). In addition to the ICC profile, it is recommended to embed the color rendering method (rendering intent) to be used for the output in the document. This ensures that this method is used when converting from RGB to CMYK.

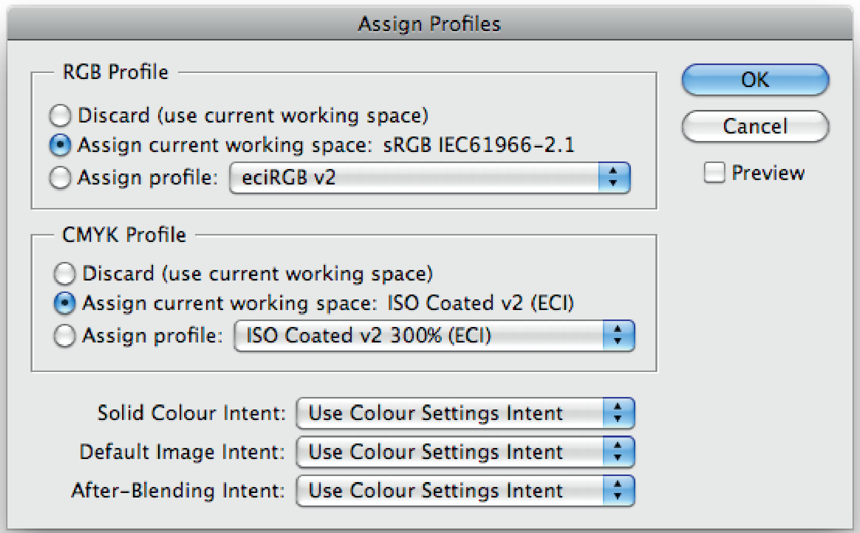


Fig. 3.11: Recommended colour settings.

QuarkXPress as of version 9

In XPress you must alter the settings defined in the source setup. Please go to QuarkXPress -> Preferences -> Print Layout -> Color Manager. Then you must go to "Source Setup" to change to the appropriate PDFX-Output Style (these must be installed beforehand). The consistent use of the print elements being prepared for the intended output conditions is also of utmost importance for XPress.

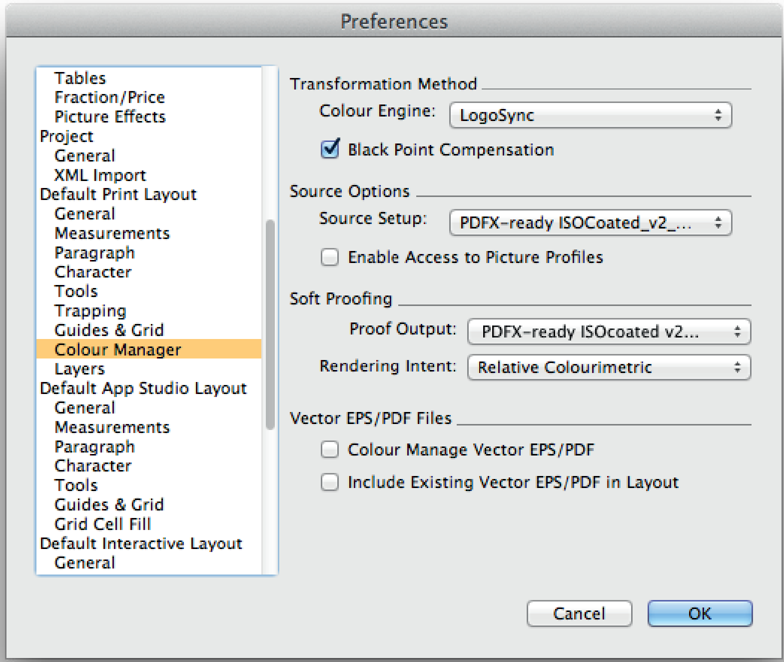


Fig. 3.12: Recommended colour settings.

Preflighting while layouting

PDFX-ready also provides default settings for the Live-Preflight of InDesign. This allows an abridged check of the data integrity already while designing and layouting the document. The PDFX-settings assure that the most important aspects of your document are correct and consistent.

The Live-Preflight does not replace the scrutiny of the final PDF! Don't forget to run the PDFX-preflight profiles after creating your PDF files.

Due to the somehow restricted functionality of the current live preflight, it can't be compared to the fully fledged «normal» preflight profiles. They typically check for different criteria. Because of that the live preflight can be thought of as providing additional information during the layout phase. It helps you to detect problems even faster.

However the live preflight does not allow for a weighting of the different instances by means of information, warning and error. No source of problem or error is an individual criteria ultimately resulting in print problems. Many reported errors have informative or warning characters and are therefore subject for individual, job specific assessment.

Furthermore additional problems might occur when exporting the PDF since later conversions such as flattening or colour conversion might change the intended appearance. Please carefully check the final PDF.

You can download the Live-Preflight-profiles for InDesign with an installation file at www.pdfx-ready.ch.

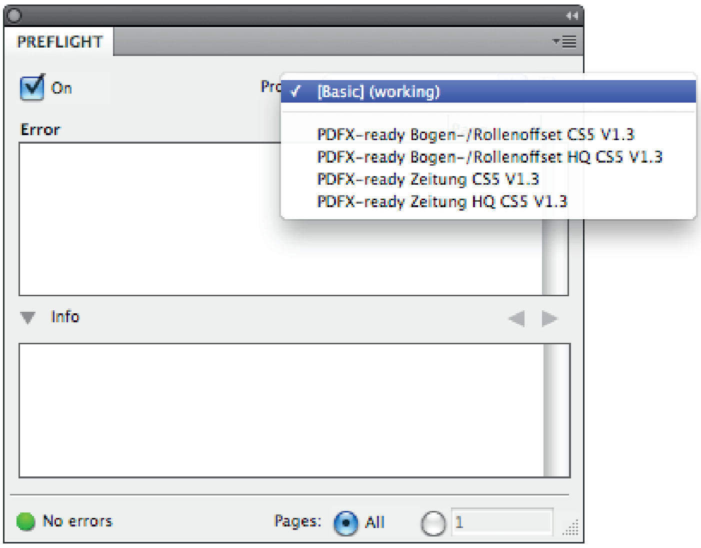
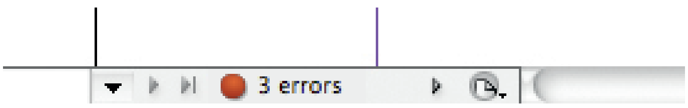


Fig. 3.13: Visualizing of the four PDFX-ready profiles to be used for life preflight during the layout-process (Adobe InDesign).

At the bottom of the window the number of occurrences will be displayed:



The results will be reported in the info section. Double clicking will select the error in the document.

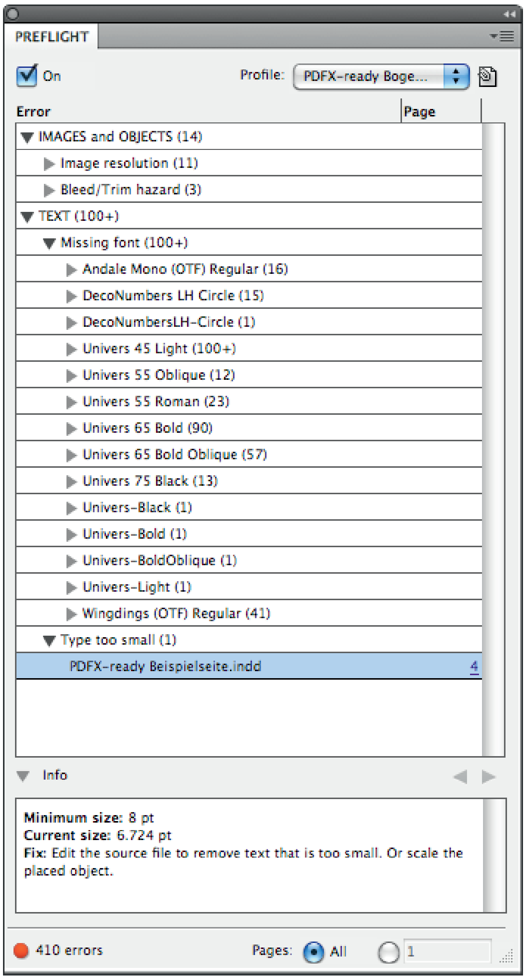


Fig. 3.14: Results of a so called Live-Preflight in Adobe InDesign

Recipe
D
Simply Rip out

Design a layout

For the design of the layout there are two different approaches:

- Process specific (optimized or prepared for given printing conditions): All images must be separated for the defined output intent. At the same time this printing condition reflects the document-CMYK colour space.
- Media neutral (optimized for viewing the image on a monitor instead of a concrete print): Images not separated, i.e. media neutrally defined in RGB will be placed, while the layout application or the following workflow step is responsible for the PDF creation including the conversion to CMYK.

All other print elements shall be prepared in CMYK. Always use the CMYK values that fit to the intended output condition. If you are not sure make a hard or a softproof. Workflows, which are using media relative (RGB) linework, are currently considered risky and impracticle. The layout itself therefore is still process or media specific.

The test layout on the right illustrates examples for both strategies.

What are optimal values?

The question as to which extent a separation is appropriate for a given printing process basically depends on the screening used as well as the colorimetrical and print related properties of used printing process. Typical examples are the registration accuracy, the tonal range, the size of the hairlines, smallest reproducible dots the screening frequency or the maximum tone values sum (TVS).

If those properties are carefully addressed when preparing print documents the resulting tone values are termed «optimal values». Typical recommendations are:

- To only use K for black text
- To avoid tone values below approx. 10% (since they might not be reproduced in a reliable fashion).
- To select a black generation strategy that uses more black which is less prone to deviations along the print run (e. g. CMYK=0,0,0,50 instead of CMYK=45,36,36,0)

Fig. 3.15: Practical hints for the process specific way of making a layout in Adobe InDesign

Optimize layouts with transparency

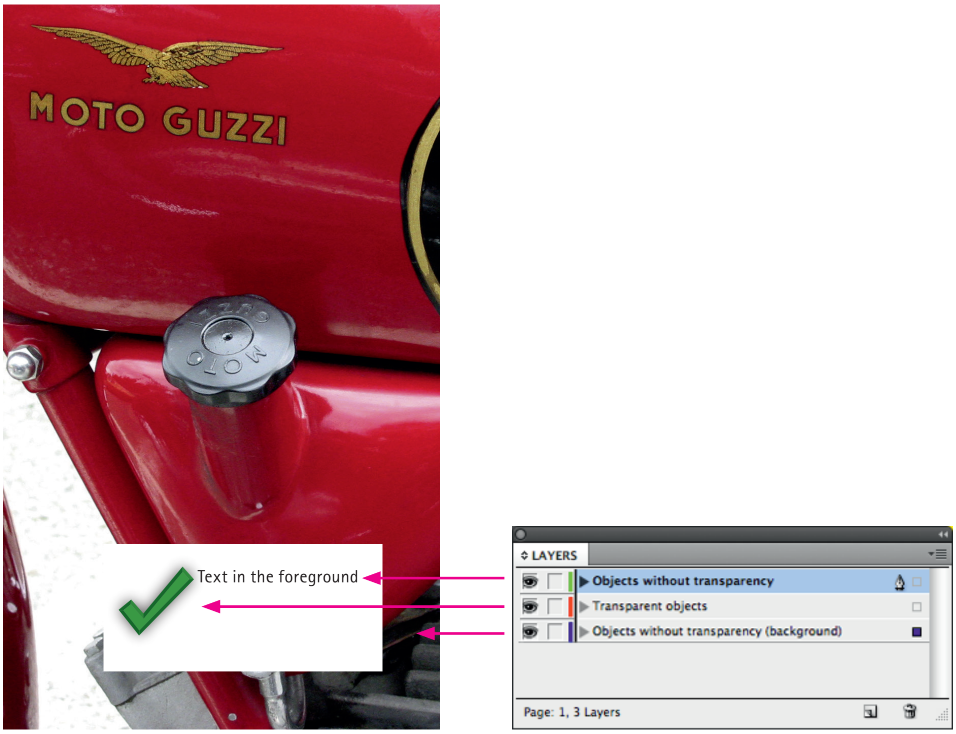
In cases where it is not possible to use live transparencies you can use the PDFX-ready V1-Workflow. However, PDFX-ready recommends to optimize the layout before flattening the transparent objects. This assures the best possible flattening result.
Some of these optimizations are also useful for for PDFX-ready V2 workflow. The quality of the resulting PDF documents will be increased, and they are less prone to processing errors downstream.

Adjust object stacking

Reducing or resolving transparencies can be conducted in both in InDesign and QuarkX-Press and is always done from the foreground to the background. Therefore the stacking sequence of the overlapping objects plays an important role. In order to avoid unnecessary transformations, e.g. of text, transparent objects should be arranged backwards. Conversely, non-transparent (opaque) objects should be brought to the front. Using additional layers might be helpful in separating objects with and without transparency and checking for the right stacking order.

TIP

When using the output preview there is the so called object inspector. It allows you to identify the individual ordering of all objects. This helps to identify the correct structure.



Text-displayer-sandwiches

A classical layout situation is to link an image with the text frame. In order to optimise this line up for a transparency reduction you might want to build a "sandwich". At the background there is the empty frame with the drop shadow. The next object is the text, followed by the image frame with displaying character. In the end it looks the same, but the text preserves it character as a text object without a transformation.

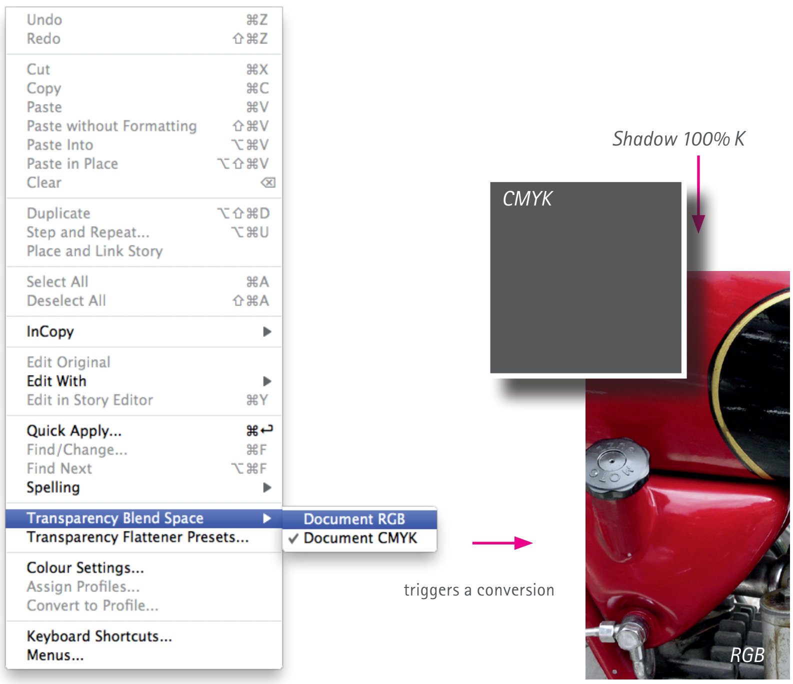
Avoid overlapping frames

In many instances the flattening process is not governed by the content of the frame but by the frame itself! Therefore conversions can be found even though image content does not overlap or "touch" visually. Please pay attention to avoid overlapping frames.

Recognizing both techniques – adjusting object stacking and avoiding overlapping frames – you can avoid most of the problems that are related to the flattening of live transparencies.

Transparency and Colour management

With the advent of transparencies colour management got an additional dimension: There are layout constellations by means for overlapping elements encoded in different colour spaces that must be resolved. A good example is the RGB-image that is overlapped by a CMYK-based drop shadow. For the overlapping area a decision must be made: RGB or CMYK?



An RGB-based image is overlapped by a CMYK based shadow. Here the image will be converted.

The decision is governed by the so called transparency blend space. When using InDesign the chosen blend space affects the entire page while QuarkXPress only incorporates those objects that are part of the individual transparency group.
In InDesign you can select the transparency blend space by clicking Edit -> Transparency Blend Space either as Document-CMYK or -RGB.

Fogra recommends to use Document-CMYK. In QuarkXPress the blend space will be defined by the PDF output style. All PDFX-ready settings define it as CMYK. Also, in cases when there is no flattening (and the final PDF is version 1.4 or higher), the definition of the transparency blend space might be of importance. That is the case for later flattening processes or colour conversions.

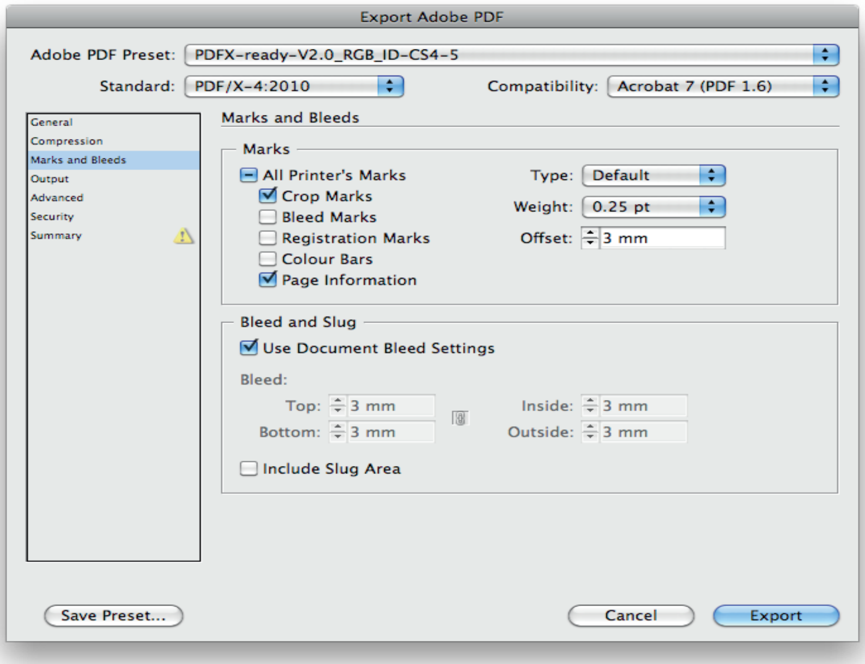
Spot colours and transparency
Layouts using transparencies should only use spot colours when they are subject for actual printing (that is admittedly the case in general). Since flattened spot colours can't be resolved to CMYK, those conversions should be done when layouting the document. PDF-documents using live-transparency clearly benefit here since spot colours stay as is and can be easily rendered at the time of the final output.

PDF/X-Creation

Many concepts and settings intermingle to finally result a PDF/X compliant file. The recommended settings therefore represent a wise balance between the highest quality and maximum security in order to achieve a consistent result. The following pages contain basic concepts and guidelines for high quality PDF/X creation both for Quark XPress and Adobe InDesign. They include an explanation about the implicit and explicit implications.

Marks and Bleeds

All printer marks such as crop or registration marks are used only for visualization. In order to interpret the geometric information correctly modern imposition tools rely on the boxes that are encoded in the PDF file. The TrimBox, for instance, defines the intended dimensions of the finished page after trimming. PDF-X-ready follows the "less is more" principle and includes only the crop mark and page information.



PDF Export Settings

1. Compression – Downsampling:

Downsampling determines the effective resolution to which the selected objects are recalculated. The effective resolution is governed by the intrinsic resolution of an image and the scaling applied within the layout application. For example, a 600 ppi image scaled to 50% has an effective resolution of 1200 dpi. The downsampling is triggered by the threshold that indicated when to enable downsampling. PDFX-ready workflows has downsampling disabled by default. This is based on the finding that high quality images might suffer from a non appropriate downsampling operation. Certainly the resulting documents require more memory. PDFX-ready recommends to prepare images for their effective resolution. This allows for images with high detail sharpness to have a moderate file size. Optionally you can enable downsampling, when required.

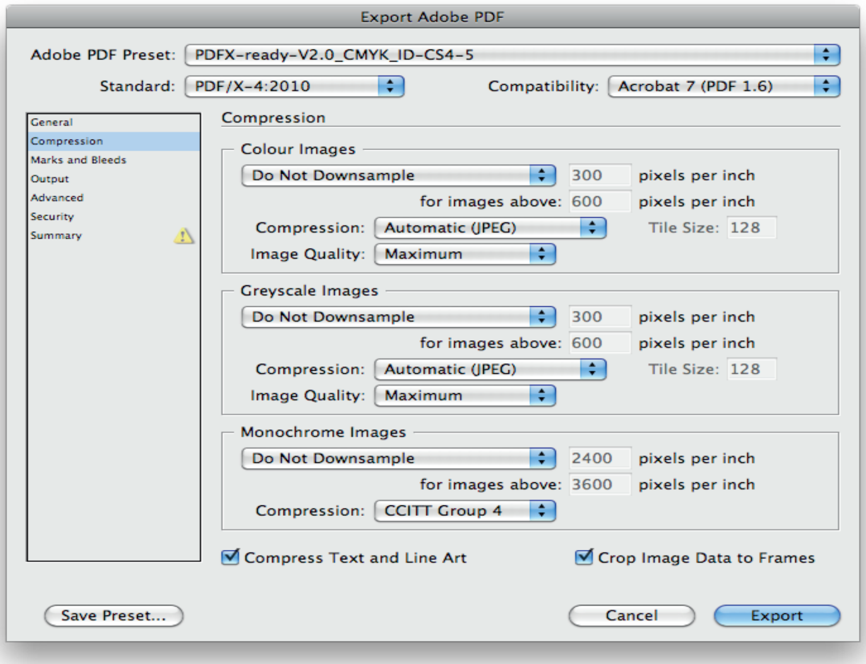
Hint:
In order to estimate the correct image resolution please have a look at the examples provided in chapter 2 (2.5.5). They incorporate scaling and intended viewing distance, which are needed to understand the entire picture.

A good approximation for the needed image resolution can be determined as followed:
Res. = line width (screening) x 2.54 x quality factor
The quality- or safety factor is typically set to 1.5 for newspaper application and 2 for commercial printing. For non-periodic screens the resolution might be higher. As a rule of thumb the resolution should be higher for high-contrast images than for low-contrast.

2. Re-Calculation method
There are different methods to perform the downsampling. The best quality is typically achieved by using the bicubic downsampling.

3. Re-Calculation threshold
It makes no sense to downsample a image from 304 ppi to 300 ppi. In order to utilize the downsampling in a useful fashion you can define the resolution at which the downsampling starts. For images above that threshold value the recalculation applies. It therefore allows for a buffer, also known as head room, to avoid unnecessary downsampling. Since PDFX-ready recommends disabling downsampling this parameter is obsolete. However, if you plan to use downsampling it is recommended to use a number that equals twice the value to be downsampled. In other words, if you want to set a image resolution of 300 ppi you should define 600 ppi. That procedure avoids inappropriate subsampling. QuarkXPress does not offer such a mechanism. Therefore it is recommended to set the downsampling value to 600 ppi. This assures that images comprising an intrinsic resolution under 600 ppi won't be touched.

Hint:
The value "304 dpi" is based on a non metric calculation of the screening resolution. A screening resolution with 60/cm relates to 60*2.54=152.2 lpi (lines per inch). If you apply the safety factor 2 ....



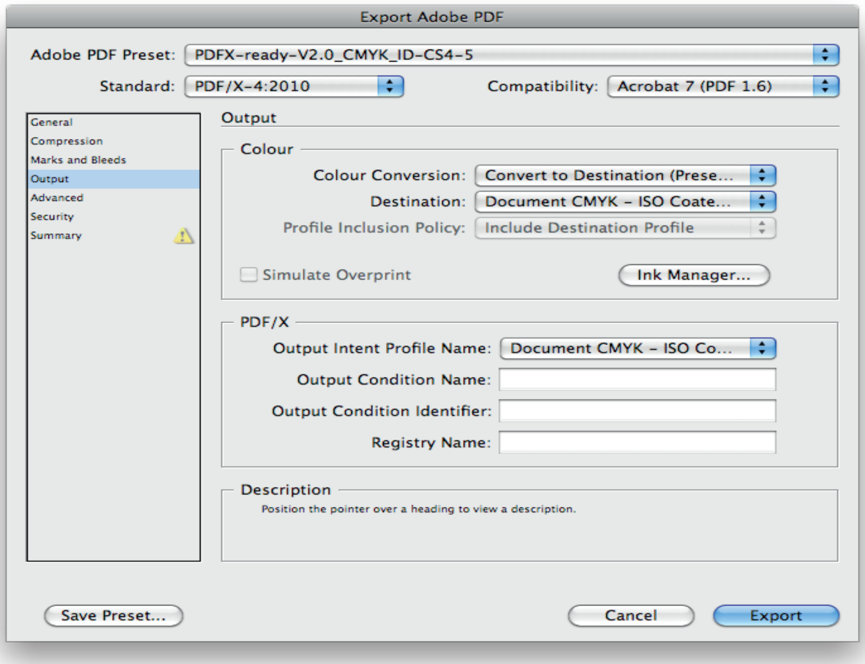
4. Compression
Not compressing images when creating a PDF is a waste of memory. The type of compression depends on both the individual preferences and some technical requirements. PDF/X-4 offers two kinds of lossless compression, namely ZIP and JPEG2000. In case of the conventional JPEG compression there are a range of lossy compressions. Due to current performance restrictions by using JPEG2000 (see box) PDFX-ready recommends the usage

Hint:
LZW is the acronym for the inventors of the lossless compression; Abraham Lempel, Jacob Ziv, Terry Welch.

of JPEG with maximum quality. Here InDesign uses a mechanism that analyses the image content in order to select the optimal compression schema. Less contrasty images typically are compressed using the JPEG algorithm while contrasty images are compressed with the lossless ZIP method. Especially in the latter case technical tones (e. g. screenshots) benefits. ZIP compression on the other hand won't result in a blurring appearance around text (also known as a "halo"), hence the legibility will be increased.

Colour settings for PDF export

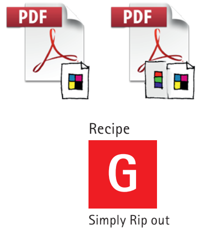
PDFX-ready export settings for InDesign use the selected document profile as the output intent, i.e. the destination profile. This allows for a generic list of settings for PDF creation that does not depend on a fix output profile. This is the case since InDesign uses the document profile instead of a profile defined in the output settings. When the output profile is CMYK all placed RGB-elements will be converted to CMYK at the time of export. At the same time the document profile will be used as the output profile. QuarkXPress does not offer to use the document profile as the output intent. You must be cautious using the document profile when exporting the PDF.



Threshold for font embedding

This value defines the percentage of characters effectively used in the document to be embedded as a subset. Since that function is only applicable for PostScript-Type-1-fonts and nowadays mostly OpenType fonts are used (and they will always be embedded), this value is of secondary importance and should be set to 0%.

InDesign: Export as PDF/X for PDFX-ready V1 and V2 CMYK



PDFX-ready V2 PDF-Export from InDesign

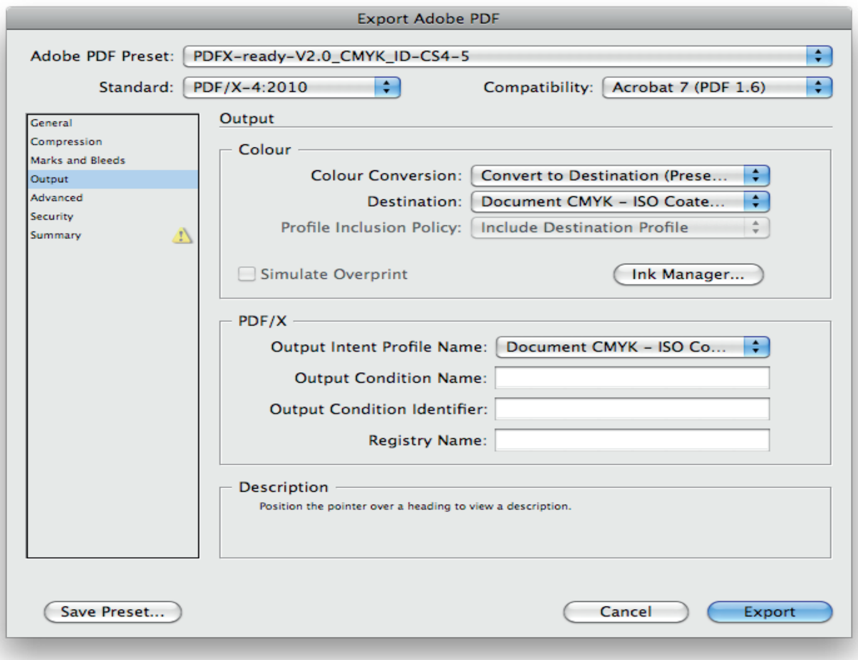
The PDF-file format as of version 1.4 allows for objects that are not defined in PostScript (that means printing a PS or EPS file and using Distiller to create the PDF file). In order to not compromise the quality it is recommended to use the direct PDF export. In this case it is not needed to flatten documents. Hence PDFX-ready settings only cover export settings and no Distiller settings anymore.

The PDF/X-Standard

The PDFX-ready V2-specification is based on the PDF/X-4-standard. Currently only Adobe CS products (as of CS 4) provide a PDF/X-4 support. InDesign allows here for a direct PDF/X-4 compliant output.

PDFX-ready V2 CMYK-PDF-export settings are mostly based on the PDFX-ready V1-PDF-export settings. They differ in three important aspects namely:

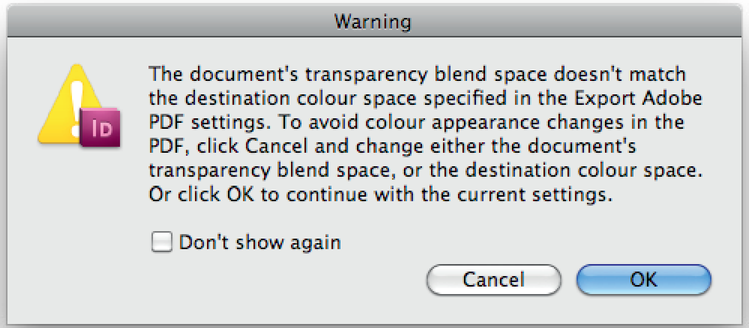
- **Conformance Level:** PDF/X-4
- **Compatible**: PDF 1.4 or PDF 1.6 (as of InDesign CS 5.5)
- **Transparency:** live transparency



Using both PDFX-ready workflows V1 and V2 all print elements will be converted and stored as CMYK. Here elements already encoded as CMYK stay unchanged. However while the transparencies will be flattened when exporting PDF with the V1-settings they stay "Live" when using PDFX-ready V2 export settings. These settings are suitable for early binding as well as for intermediate binding.

Transparency-Blend-Space

PDFX-ready V2 CMYK does not allow RGB based transparency blend spaces. CMYK blend spaces that differ from the document colour space will be changed to the "document colour space" when creating the PDF. Since this procedure is not considered to be a colour conversion, this mismatch will result in an error message (see screenshot below).
The modification of the transparency blending space might lead to a different appearance. In that case PDFX-ready recommends correcting the data. If that is not possible, the received (uncorrected) PDF should be visually checked by means of a soft or hard copy proof.



Hint:
The greater the color difference per color channel between objects within a group with transparent objects, the greater the visual difference when changing the transparency transition color space from an RGB color space to CMYK.
.

Attention!

You will not receive a warning when placing PDF documents that use RGB based transparency blending spaces into InDesign. Instead it uses the actually used blending space. A warning won't show up before creating the PDF at the export phase.
For that reason please check the PDF files before placing them with respect to the used transparency blending spaces. In Acrobat 9/X Pro you can identify the used transparency blending space by using the flattener preview ("Page-Level Transparency Blending Color Space"). Here you can alter them.

Recipe H Simply Rip out

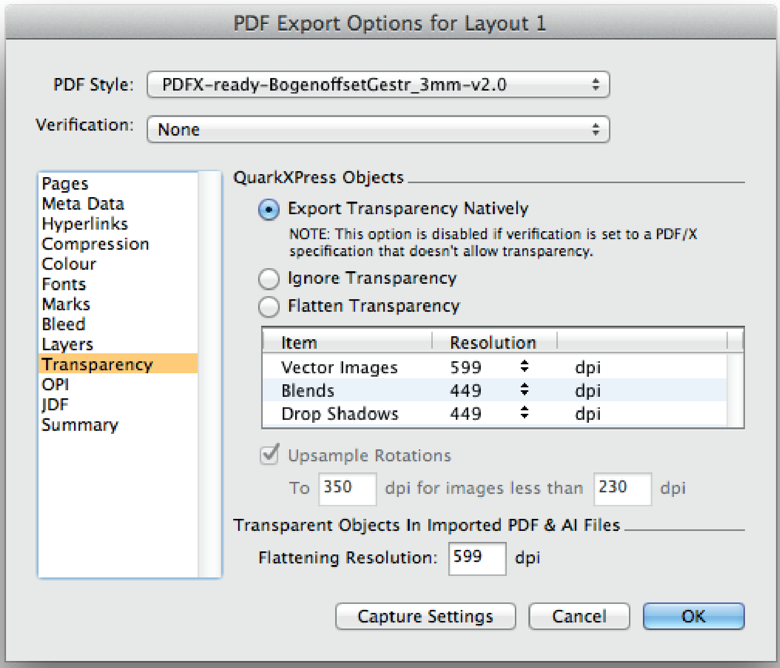
QuarkXPress: Export as PDF/X CMYK

The PDF/X-Standard

The PDFX-ready V2-specification is based on the PDF/X-4-standard. The current version of Quark XPress does not support a direct, PDF/X-4 compliant, PDF export. Contentwise it allows compliance with all normative PDFX-ready V2 requirements. Therefore a PDF exported from QuarkXPress can be converted to comply with PDFX-ready V2 requirements by means of Acrobat PDF-preflight (fixups).

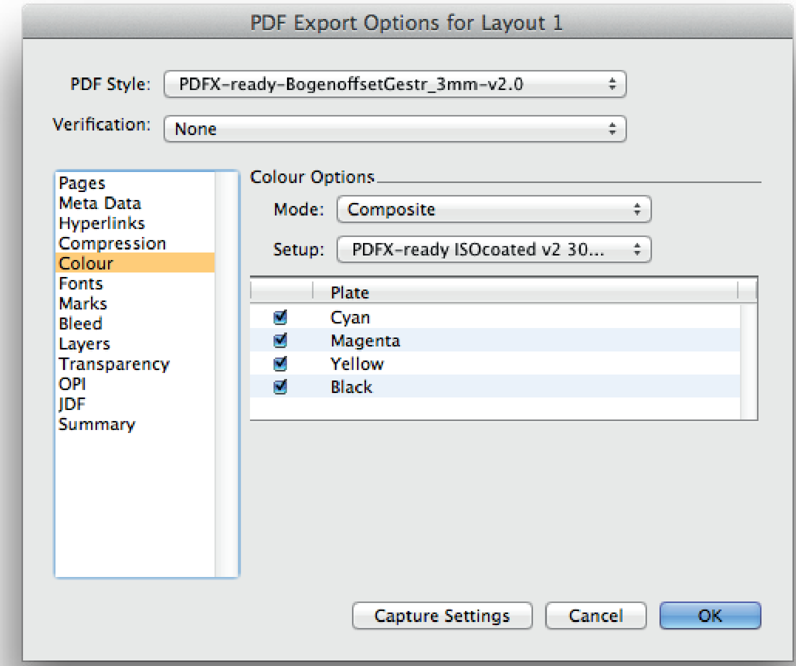
PDFX-ready V2 PDF-Export settings in QuarkXPress

The PDF-file format as of version 1.4 allows for objects that are not defined in PostScript (that means printing a PS or EPS-file and using Distiller to create the PDF file). The current version of Quark XPress uses PostScript “under the hood”.
However, the used method results in PDF files that contain live transparencies that are capable of complying with the following PDF/X-4 requirements.
The only drawback is related the imported transparencies. Here it must be stated that Quark XPress is unable to interpret live transparencies as part of PDF or AI documents.



As of QuarkXPress 10, transparencies are retained in imported images. In older versions, the layout program cannot handle transparency effects from imported PDF or Illustrator AI. These are reduced by XPress itself. Since this often leads to qualitative problems, it is recommended:

- to save the PDF document as a PDF/X-1a document (here no transparencies are allowed) and
- to save Illustrator-graphics in EPS format. This forces Adobe Illustrator to flatten the transparencies, which typically results in higher quality documents compared to Quark XPress. The transparency effects will be preserved as long as Illustrator is used.



PDFX-ready V2 CMYK-PDF-export settings are mostly based on the established PDFX-ready V1-PDF-export settings. They differ in two aspects namely:
¬ Preflight: No standard, since there is no support for PDF/X-4
¬ Transparency: Native export

When creating the PDF both by using PDFX-ready V1 or PDFX-ready V2 CMYK, all placed elements will be converted to the CMYK-profile that is defined in the colour settings. Elements that are already defined in CMYK stay the same. While the export according to PDFX-ready V1 results in a flattened document, live-transparencies will be preserved when using the PDFX-ready V2 export settings. These export settings are suitable for early binding and Intermediate Binding workflows.

Converting QuarkXPress-PDF into PDF/X-4
Since the PDF created by XPress is not a valid PDF/X-file, it must be "finetuned" by means of an additional Acrobat Preflight fixup profile. Convert the PDF into PDF/X by using the fixup profiles provided by PDFX-ready at www.pdfxready.ch. In case your are using an output condition that is not covered right now, you can easily modify an existing profile that suits your needs. Please note that the PDFX-ready profiles do not change the colour values. Hence all elements must be correctly prepared for the intended output condition.

Recipe

Simply Rip out

3.3.2 Inspecting PDF: Preflight

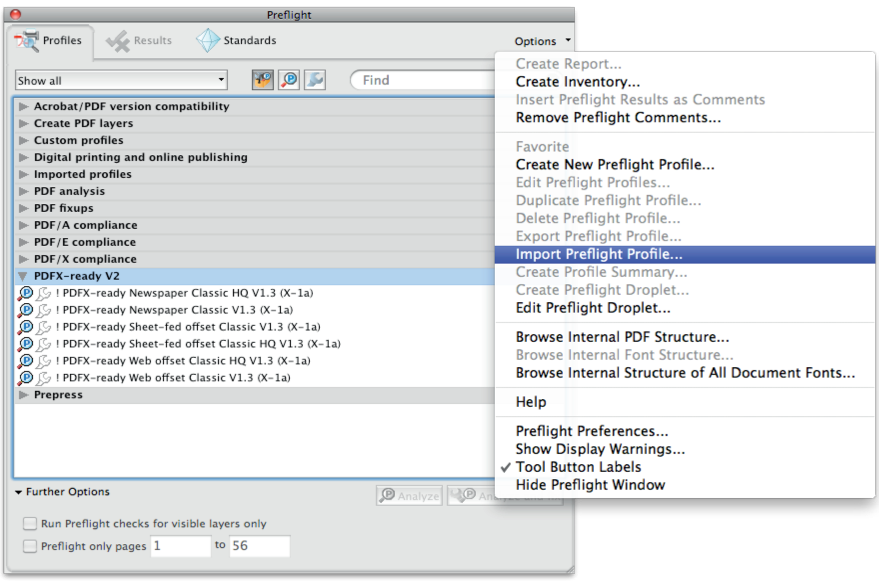
Inspecting the final PDF file (Preflight) is an essential part of a PDF workflow. The settings provided by PDFX-ready for preparing and creating print-ready PDF documents should be considered guidelines that could be used and altered when needed.
Basically there are three levels of preflight: Checking data and flagging problems while you work in the layouting phase (see C), before you send the PDF documents to the service provider and when receiving PDF documents for the final output.
The PDFX-ready preflight profiles should be run without any error messages. You can download the profiles together with installation instructions at www.pdfx-ready.ch.

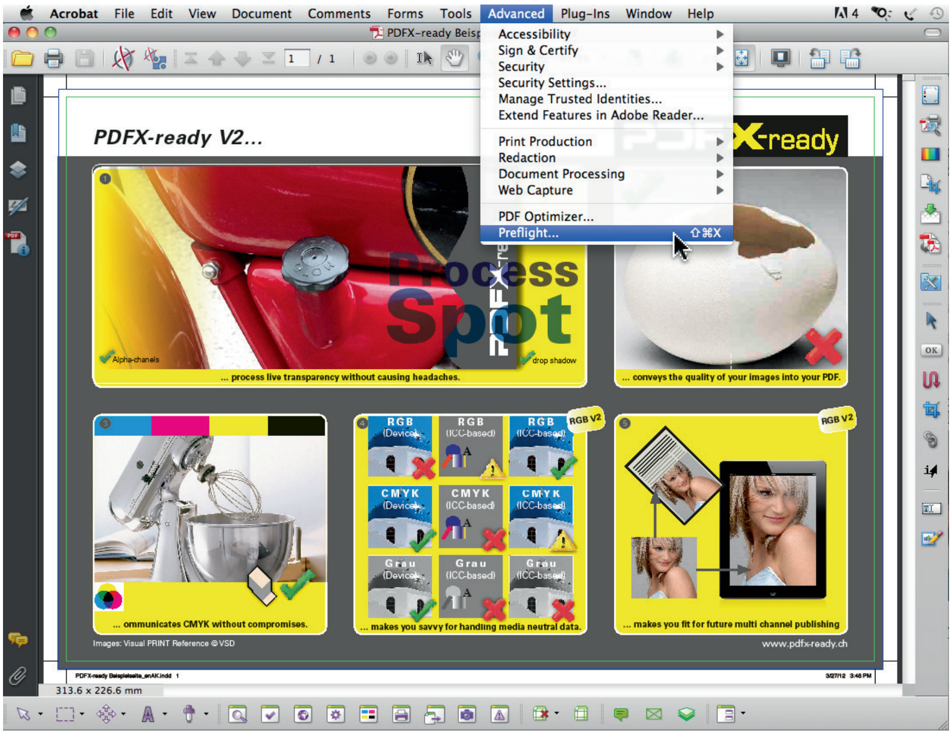
Hint:

The installation details can be found next to the preflight profiles at www.pdfx-ready.ch.

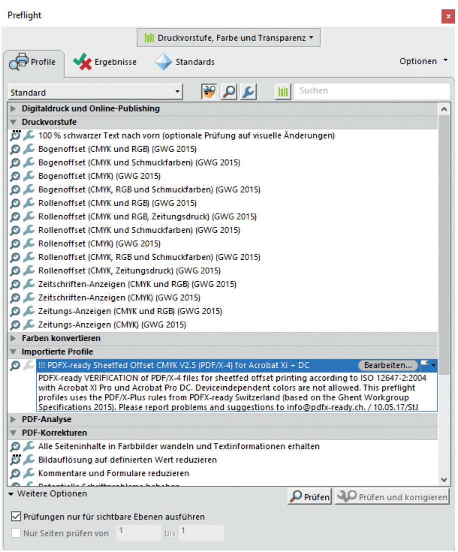
PDF-Preflight in three steps

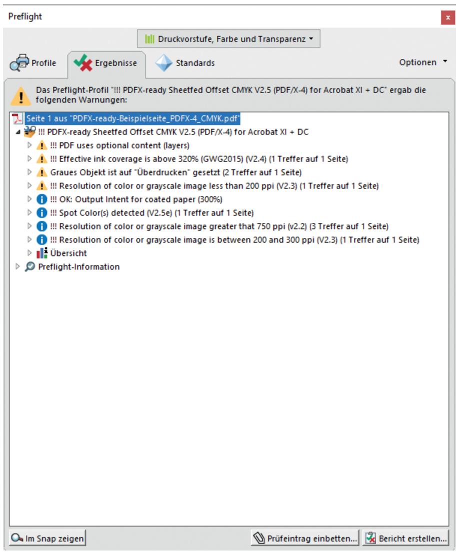
Step 1: Download and install preflight profile. You can easily install the PDFX-ready preflight profiles - illustrated here for Adobe Acrobat 9 Pro – by importing them or via Drag & Drop. Start the preflight menu. The "Preflight" function is located in Acrobat in the "Advanced" menu.





Step 2: Analysing the PDF/X-file. In this case the profile "PDFX-ready Sheetfed Offset-CMYK_V25_(PDF/X-4) for Acrobat XI +DC " is used.





Step 3: Results: The file has passed the preflight as check by "PDFX-ready Sheetfed Offset-CMYK_V25_(PDF/X-4) for Acrobat XI +DC".

Attention:

In addition to the synchronization of the color settings via Adobe Bridge, there are also a few relevant default settings in Acrobat for PDF / X: In the "Page display" tab, it is recommended to use the options "Show object, trim and bleed frames" and Activate "Always show the page format of the document". Additionally, you should set the «Preview for overprinting» to «Automatic». This also enables the overprint preview for non-PDF / X files.

Can I edit the preflight profiles to suit my needs?

Sure thing! The checks represent a starting basis. In all cases it is OK to add more stringent requirements, but it is not OK to loosen the requirements. It is also OK to increase the image resolution if needed or add individual rules reflecting your "house standard".
It is not recommended to weaken existing checks or to delete them at all. This might lead to significant problems such as a service provider who rejects the PDF documents.

How to weigh the preflight results

Simply use three groups:

- "Errors" refer to K.-O.-criteria which might lead to reduced quality and potential problems at a later processing stage.
- "Warnings" alert you to double-check the findings on an individual basis. This can help you discover errors.
- "Information" are hints that are not directly related to the final print product.

PDF that show "errors" are not in conformance with the PDFX-ready spec. However, PDF-files that only show "warnings" and/or "information" can be considered print ready.

Recipe
J
Simply Rip out

Recipe
K
Simply Rip out

3.4 Printer guidelines for optimized PDF handling

3.4.1 Creating print-ready PDF-files

What are the reasons for a print service provider to convert colours?

- Process conversion: The main reason for doing a process conversion is illustrated on pages 134 and 135 – colours defined by the PDF won't match with the actual printing condition. In order to achieve the desired appearance the data must be converted. However, when Output Intent and actual printing condition match there might be a need for a conversion.
- Modify total ink coverage: Reducing the total ink coverage (tone value sum), say from 330 % to 280 %, or even less, might help to increase print stability. Typically there is less potential for blocking, and faster drying.
- Ink Saving: In particular for higher run length an ink saving file conversion might help to reduce ink costs. Using a separation that is tailored for the pertinent printing condition usually helps to improve print quality and increases process stability.

While the process conversion toward a different output condition can be done by the data creator, modifications such as total ink coverage reduction or ink saving algorithms are to be done by the print service provider.
Conventional ICC-based approaches, e. g. done in Adobe Photoshop, are not capable of performing colour conversions for complex documents that contain images, text and vectors. In fact, state of the art colour servers are needed to perform the needed CMYK-to-CMYK-conversions. Here dedicated DeviceLink-profiles do the work under the hood. What is so special about these profiles and how do they work?

Re-Purposing and Re-Targeting

Preparing print-ready data requires the knowledge of the intended printing condition including all pros and cons. When the Output Intent is missing or wrong there are two aspects to be taken into consideration. In case of colorimetrically characterized image data a preparation for the actual printing condition is doable. However when tone values (used as „technical tones“ or „Info Colour“) without any colorimetrical description are used there are some pitfalls.
Often print service providers are required to create or produce PDF/X compliant data. Without a colorimetrical description of the print elements (e. g. by means of appropriate source profiles) and without the knowledge of the intended printing condition there is no unambiguous way forward. A practical work-around is using suitable source profiles (by means of empirical findings and educated guesses) and de-facto printing conditions established in the pertinent market sector. Such a de-facto printing condition is FOGRA51, i. e. offset-printing according to ISO 12647-2:2013 on coated stock using a screening according to 60/cm. Untagged CMYK-print elements are therefore interpreted as if they have been prepared for FOGRA51 (or the recommended ICC-profile, being PSO Coated V3 (ECI)).
Since digital printing conditions barely reflect FOGRA51 fully, a dedicated device link transformation can be established that will transform the data from FOGRA51 (reference) to an actual (digital) printing condition. Going from the „reference“ to the „actual“ printing condition there are two different types of transformation. The first is called „re-targeting“.

This transformations tries to achieve the intended colorimetry as good as possible and could be considered as proofing-like. It basically reflects similar gamuts and an absolute or media relative colorimetrical transformation. The second transformation is called „re-purposing". Its purpose is to re-render the document appearance to the new (actual) printing conditions to its best extent. This is very much appearance and preference based and therefore subject to the different vendors implementation including gamut expansion. The selection of the suitable transformation depends on the customers requirements. In light of the predictability of the image content, re-targeting transformations are recommended since they allow either for 'printing the expected' or indicating the need to change the actual printing condition. Re-purposing transformations can be successfully used in some applications, but theie use should be communicated to the data provider.

The guideline uses different symbols:

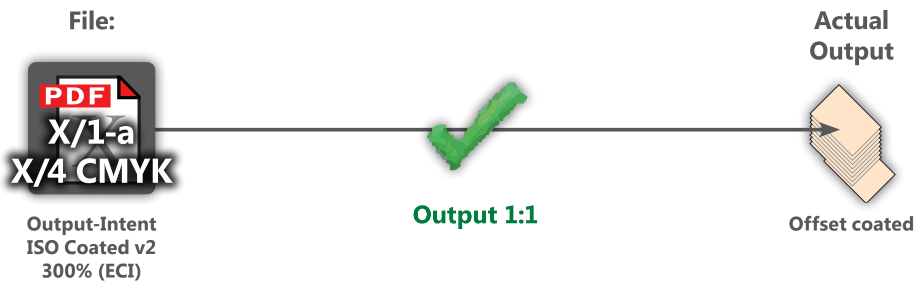
The tick shows, that a process, a result etc is O. K.

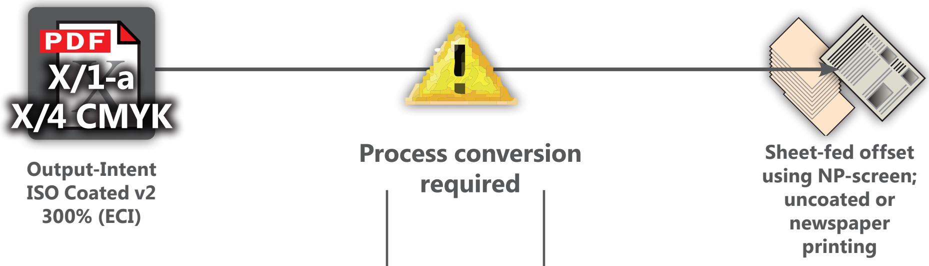
The red "X" shows an "error" or a criterion which inevitably will lead to problems.

If a "warning", as indicated by the yellow warning sign, is to be treated as problematic or not depends on your decision.

An "information", marked by the blue information symbol, shows additional explanation and only seldomly leads to real problems.

„What happens when" – Recommendations when Output Intent and actual printing conditions don't match



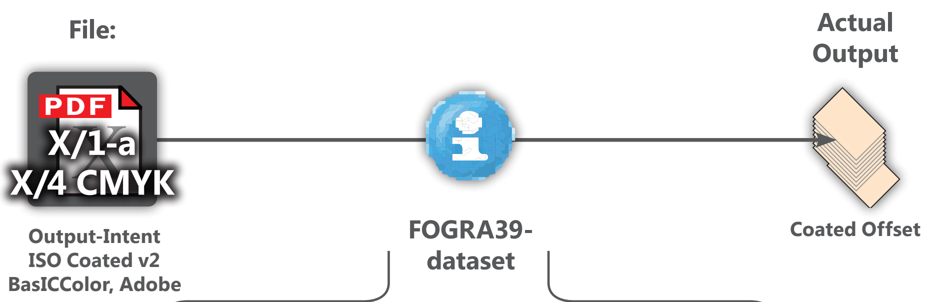


Appropriate action: Convert the entire document by means of a colour server using dedicated ICC-profiles (to preserve channels or black text), if needed create a new proof

Appropriate action: Contact data creator and request properly separated data

Inapropriate action: Ignore Output-Intent, Output data 1:1

Inapropriate action: Convert entire document by means of conventional ICC profiles that lack to preserve channels (pure colours and black text will be «contaminated»)



No file conversion needed, since PDF/X-Output Intent and actual printing condition matches

Inapropriate action: Convert entire document by means of conventional ICC profiles that lack to preserve channels (pure colours and black text will be «contaminated»)

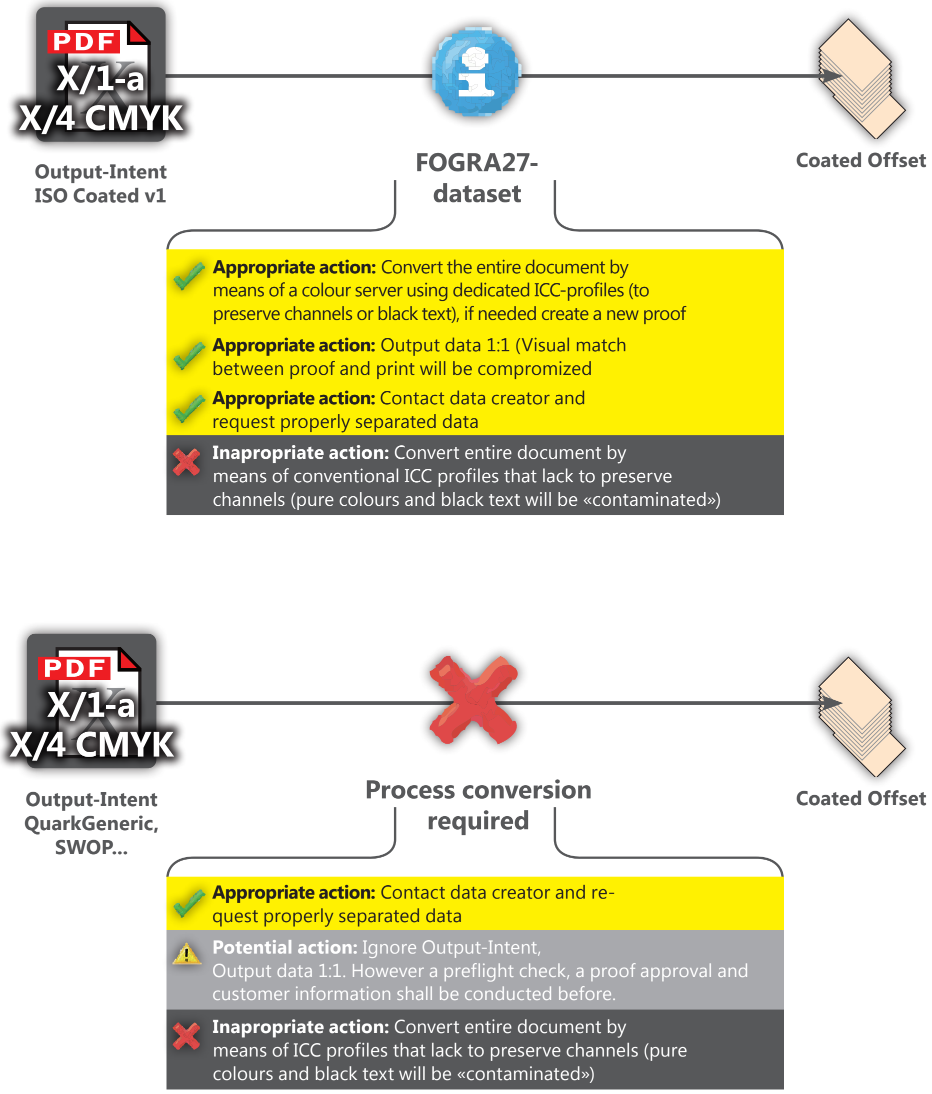


Fig. 3.16: Overview of appropriate and not appropriate file conversion

A typical colour workflow is depicted in Figure 3.17. First sRGB or AdobeRGB-data is prepared for the printing condition FOGRA39 that serves as the reference. The aforementioned transformations „re-targeting" and „re-purposing" are illustrated for the subsequent transformation from the reference to the actual printing condition.

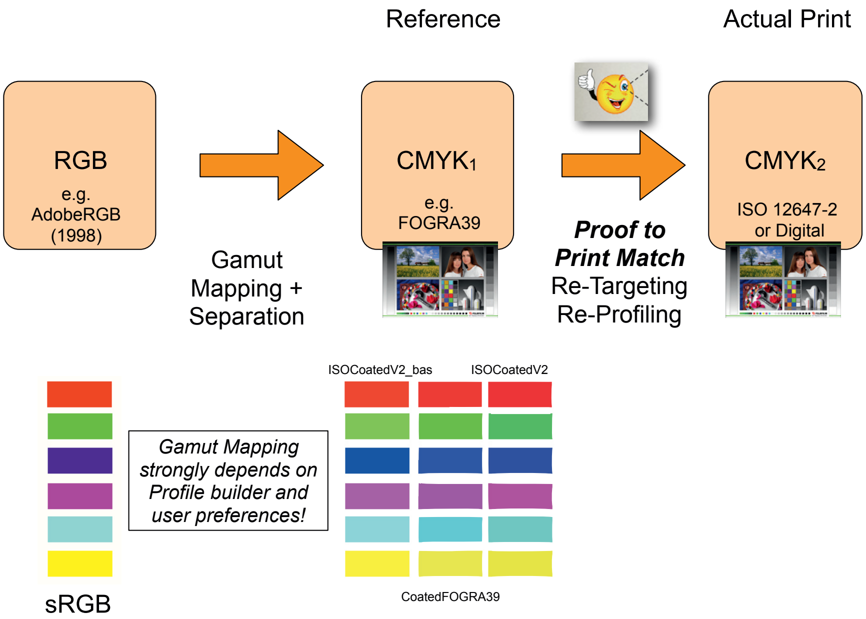


Fig. 3.17: Illustration of the different ICC-profiles that are based on FOGRA39 but result in different separations. Since there is currently no standardized or agreed upon way of mapping colours for this purpose the preparation steps represent an artistic intent and are subject of the creative work. However creators are able to view the final result as a soft proof, Contract Proof or Validation Print.

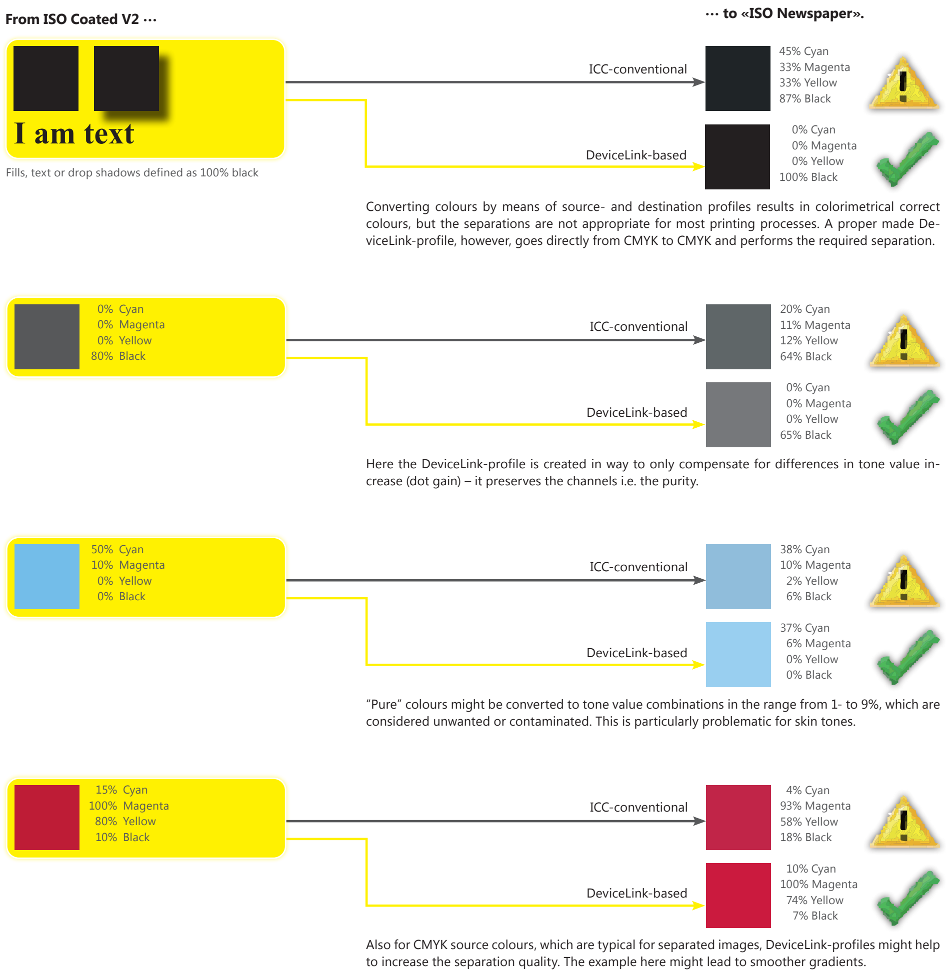


Fig. 3.18: Example conversions showed for both conventional ICC (top view) and DeviceLink-based (bottom). The concrete values have been taken for the re-separation from FOGRA39, i. e. ISOCoated V2 (ECI) towards IFRA26 (newspaper printing) .

PDFX-ready V2-Processing

PDF/X-1a, which is bases on PDF 1.4, is a data format that can be converted to PostScript without any problems. This holds true for the other way around. All PDF-workflow systems, that use a "Configurable PostScript Interpreter" (CPSI) convert the entire document to PostScript before processing at the RIP. Processing such PDF/X-1a- (or PDF-1.4-) files is, in light of the high number of PostScript based workflow systems in use, therefore not difficult. Quality-wise differences are usually seen by PDF-to-PostScript- and PostScript-to-PDF-conversion programs.

Since the usages of live transparency, as introduced with PDF-Version 1.4, more and more problems are observed when processing the PDF documents with PostScript based RIPs. The biggest issue is the correct rendering of objects using live transparency. Since PostScript does not know any live transparency, the CPSI-based system must reproduce the visual appearance as closely as possible by facilitating its opaque imaging model. That process is termed "Flattening". Only PDF based workflow systems can natively handle live transparency, which avoids any flattening. This technology allows the creation of high quality images that are needed for the imaging process, without intermediate steps.

Splitting compositions into many pieces or converting parts of a text to outlines or a bitmap should be considered outdated.
PDF/X-4 is based on Adobe PDF-version 1.6 and allows live transparency, optional content, 16-Bit-images and state of the art compression. In short, you can say that a native PDF rendering engine is needed to correctly process and output PDF/X-4-files. This technology is certainly backwards compatible and therefore able to render PDF 1.3 files. Investing into this technology allows you to consume all kinds of PDF files.

Some notes for the transition:

¬ **PDF-Creation:** A PDF/X-4 file that contains live transparency requires the direct PDF export. PDFX-ready provides updated settings for typical applications that offer a PDF export.

¬ **Proofing**: A contract proof made from a PDF/X-4-file using live transparency requires a native PDF rendering engine, otherwise the proofing system is forced to flatten the transparency, which might lead to the described problems. All major proofing manufacturers provide a native PDF-renderer. It is important that this functionality is enabled and that the PDF is not printed by using the printer-menu.

¬ **Trapping**: Object level based trapping within a PDF file requires dedicated software that has access to the effective colour (or density) of each object. In case of transparency this not possible, since the final colour value depends on the objects underneath Typical trapping software is not able to perform such a calculation. Some trapping solutions therefore flatten the PDF before starting the trapping process. This process, however, is not advisable since known flattening issues might occur. PDFX-ready recommends to preserve live transparency while trapping. Objects that are part of one transparency group will be trapped as usual. Thus the blend mode, defined by the transparency group, is valid for the created traps.

¬ **Colour conversion**: Changing colour values of individual objects might lead to problems, since DeviceLink-profiles will be applied to an object disregarding of potential transparency effects. In rare cases colour transformations might wind up with huge colour differences. The reason for this is that the colour transformation is carried out on an object-by-object level. Blending objects by means of transparency, however, represents the interaction of all objects involved. Furthermore, it can happen that the transparency effect results in a heavy darkening of the object colour. Although an image has no part with more than 300% ink coverage, after the described colour conversion it can be converted to have ink coverage values of about 350%.

In those cases there are currently three solutions:

¬ use a different transparency effect, that results in a similar appearance.

¬ flatten the relevant page

¬ apply a colour transformation after rendering of the document. The downside here is that placed control wedges will also be converted, which is typically not desired.

¬ **Imposition**: As for PDF/X-1a-files the output condition must match the document colour space. Current layout applications ignore the output intent and perform only one transformation at the final rendering of the RGB data to CMYK (instead of two). Certainly a layout program using conventional ICC colour management is the most unsuitable tool to perform a page level colour transformation. However, a warning would be highly appreciated. As long as there is no warning, the user is advised to check the placed documents in a manual fashion.
¬ **Knock-Out and Overprint:** Here the same rules apply as stipulated by PDF/X-1a. Overprint settings should he honored, unless there are important reasons not to do so. Such reasons might be:
¬ the presence of white text with enabled overprinting
¬ the presence of opaque spot colours, that would contaminate overprinting black
¬ the presence of metallic or neon spot colours

It is important both for visual inspection and proofing that overprinting will be evaluated. Working with live transparency has some clear benefits, since transparency and overprint preview can be displayed independently. Flattened PDF files, displayed without the overprint preview, will often be rendered incorrectly.

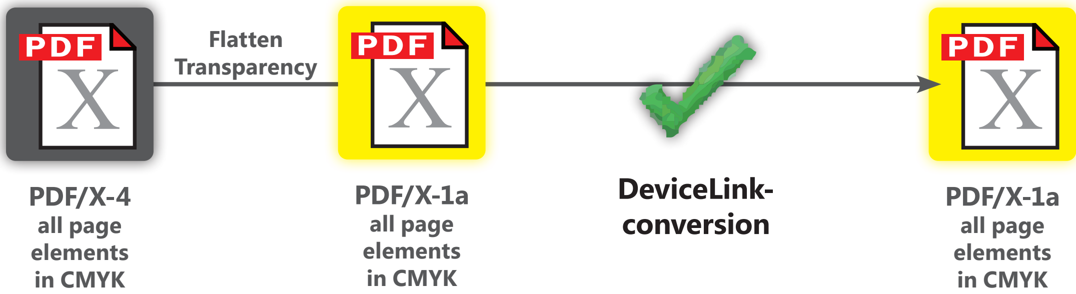
PDFX-ready V2-process conversion workflow

In order to properly render the PDF/X content for the final output device you need:
¬ Either a RIP, that allows for native PDF-rendering (such as the Adobe PDF Print Engine or Harlequin 9) or a mechanism that performs a flattening followed by a required colour conversion.
¬ PDFX-ready recommends to invest in technology that can natively render increasingly complex designs. Only by using such a technology you can run a consistent and true end-to-end native PDF workflow.

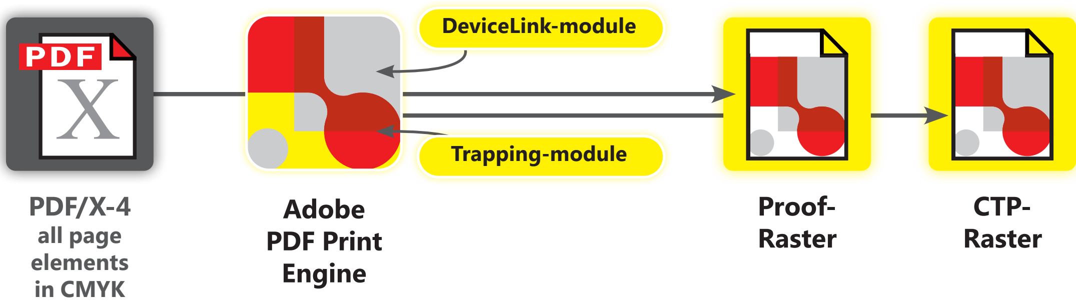
What do practical and reliable processing strategies for PDFX-ready V2 CMYK and RGB look like?

PDFX-ready V2 CMYK

DeviceLink-conversion in combination with complex transparency effects (in particular when using different blend modes) might change the final appearance quite significantly from what the creator expected. Although this conversion is doable, users should be cautious when using it. It is highly recommended to create a contract proof or a validation print to inspect the conversion result.



You can avoid this problem when converting the PDF/X-4 into PDF/X-1a before applying the Device-Link-conversion.



The best way is to simultaneously apply trapping, colour conversion, graphics handling, font processing, transparent data to render the entire job in a single, integrated operation (e.g. by using the Adobe PDF Print Engine). This allows for predictability not limited to CTP-plate setters, but also for making soft- and hardproofs. This integrated way is currently supported only by a few workflow and printing systems.

3.4.2 Practical recommendations for spot colour handling

Since InDesign CS6 many spot colour libraries (including Pantone libraries) using, next to the spot colour name, CIELAB as the alternative colour space to define a backup scenario for a given spot colour. This is no problem as long as the spot colour is printed as such, hence an additional process colour. However for digital printing the spot colour often needs to be converted to CMYK. In this case, using conventional ICC colour management, CMYK tone value combination might result, which are not appropriate for printing.
For instance "PANTONE Cool Gray 5 C", was defined as CMYK=0,0,0,29 until CS5. Using conventional ICC profiling (ISOCoatedV2) the resulting CMYK values are CMYK= 33,25,26,5. Whilst this is colorimetrically correct but might result in printing problems.
Before converting spot colours to process colours, it is therefore recommended to check the alternate colour space description and to correct it. This should be communicated with the print buyer.

3.5 Recommendations for converting Office-PDF into CMYK

The following criteria makes provisions for creating print ready data based on PDFs originating from office environments. They are intended to support service providers that have to consume such data in order to achieve a unified reproduction across different service providers. The destination profile (output condition) is ISOCoated v2 (ECI) reflecting the printing condition FOGRA39. All CMYK objects and spot colours are maintained. Line art elements defined in RGB will keep their vivid colour by means of a freely available DeviceLink profile. RGB Gray gets converted to pure Black, Black text is set to overprint.
It is planned to provide a conversion for toward PSO Coated V3 (FOGRA51) soon.

Assumptions:

Office data mostly contains objects encoded as DeviceRGB and DeviceGray. Current versions might also contain ICCbasedRGB and ICCbasedGray due to the support of PDF/A. In special cases objects are encoded as CMYK and spot colours. The colorimetrical accuracy is not of primary concern.

Workflow:

- Service provider gets office-PDF
- Transformations done according to the criteria below :
  - by means of a colour server creating a PDF/X-4 file or directly in the final RIP application
  - by means of a Digital Front End (e. g. FIERY, Creo or FFPS) for direct communica tion with the printing press
- Output: „Side-by-Side“ or media relative

Hint:
The ICC-based RGB-CMYK DeviceLink-profile was provided by basICColor. You can download it free of charge at the Fogra homepage.

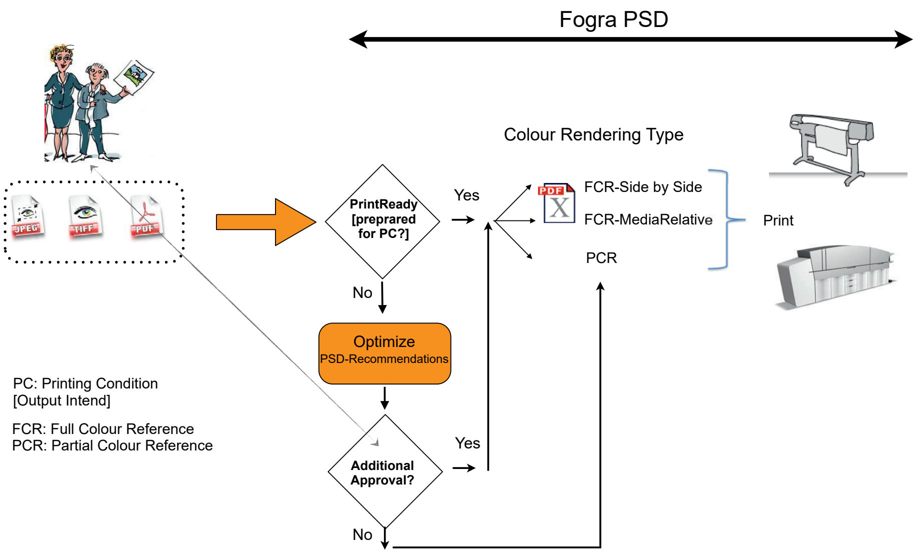


Fig. 3.19: Fogra PSD Data workflow schema. Remove ambiguity by applying typical industrial conversions. Use this guidelines to either convert to PDF/X-4 or print directly.

Rules (to be applied and in the following sequence):

Expert-
Knowledge

General:

- Always Use Rendering Intent from PDF
- If a page contains transparency and the blending space is undefined, set to it to sRGB
- Define Output Intent using the destination profile

Objects: All
Encoding: DeviceGray
How to convert: map to K-Only DeviceCMYK

Objects: All
Encoding: ICCbasedGray
How to convert: Discard Profile and map to K-Only DeviceCMYK

Objects: Images
Encoding: DeviceRGB
How to convert: Assign sRGB and convert to destination profile

Objects: Images
Encoding: ICCbasedRGB
How to convert: Keep profile and convert to destination profile

Objects: All (having R equals G equal B)
Remark: For images, this should be applied when this is true for all pixels.
Encoding: DeviceRGB and ICCbasedRGB
How to convert: Convert to K-Only DeviceCMYK

Objects: All
Encoding: Lab
How to convert: Convert to sRGB.

Objects: Line Art (including text)
Encoding: ICCbasedRGB
How to convert: Discard profile and treat as DeviceRGB

Objects: Line Art (including text)
Encoding: DeviceRGB
Apply Fogra recommend DeviceLink profile "sRGB2ISOCoatedV2.icc" for optimized colour rendering of line arts. It can be provided free of charge to any user and vendor.

Objects: All
Encoding: DeviceCMYK
How to convert: Do not convert

Objects: All
Encoding: ICCbasedCMYK
How to convert: Discard Profile

Objects: All
Encoding: Spot
How to convert: Do not convert

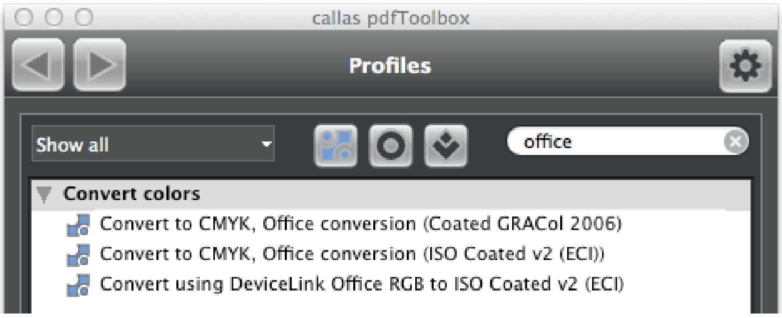
Assumptions and preparation steps for unambiguous PDF/X creation

- If page description contain transfer curve, apply transfer curves
- Assure correct nesting of page geometry boxes
- Discard all actions (including JavaScript actions)
- Discard all form submission, import and reset actions
- Discard embedded PostScript
- Embed fonts
- Make spot colour appearance consistent
- Merge annotations and form fields into page content (except "post its")
- Recompress LZW as ZIP
- If both, TrimBox and ArtBox, are defined remove ArtBox
- If ArtBox is defined and TrimBox is not defined, set TrimBox to ArtBox
- Ensure that valid creation and modification dates are present
- If Title entry is present ensure that is not empty
- Set Trapped key to „false" if Trapped key is neither „true" nor „false"
- If no TrimBox is defined set TrimBox to CropBox or, if no CropBox is defined, to MediaBox)
- Set minimum LineWidth to 0.14 pt (for LineWidth less or equal than 0.14 pt)
- For 100% black text smaller than 12 pt and 100% black thin lines less than 2 pt set overprint (Set OP to true and OPM to 1)

3.5.1 Practical use case: Company callas software GmbH

1.) Apply a PSD-based Profile onto a PDF

The pdfToolbox from callas software does have a predefined profile that is based on the PSD recommendations. The profile can be selected in the profile window in order to apply it to a PDF file. pdfToolbox Desktop can be used as standalone application, in which case the profile window can be opened via Tools - Profiles, or as Acrobat Plug-In, then via Plug-Ins - pdfToolbox 7 Profiles. In order to identify a suitable profile in the total list of profiles the search field can be used with a search term of e.g. "office".

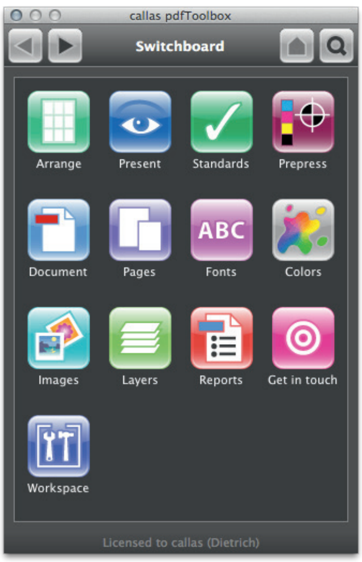


You will then see three profiles. "Convert using DeviceLink Office RGB to ISO Coated v2 (ECI)" is based on PSD. The most important difference compared to the other two profiles is that this profile does better keep distances between (RGB) colours of the original file. In comparison the other two profiles create more pure CMYK colours, e.g. 100 / 0 / 0 in RGB will be converted to exactly 0 / 100 / 100 / 0. The profile can now be selected and applied to the PDF that is open and active in the application.

Hint:

The color conversion with "Convert to CMYK, Office conversion (Coated GRACol 2006)" and "Convert to CMYK, Office conversion (ISO Coated v2 (ECI))" is based on a simple algorithm that makes sure that pure RGB colours end up in pure CMYK colours.

For users that want to use this profile frequently it can be put into the workspace that can be accessed via the pdfToolbox Switchboard. There is a small flag behind the profile name and if clicked "Workspace" can be selected. After that the Switchboard can be opened via Tools - Switchboard and the profile shows up in the Workspace group.

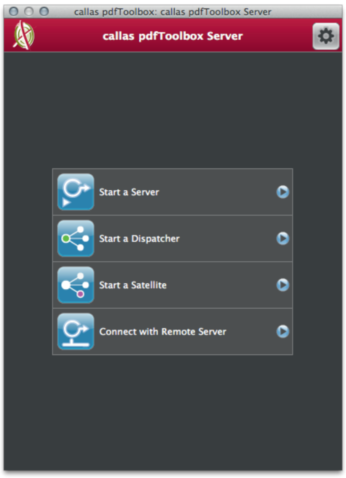


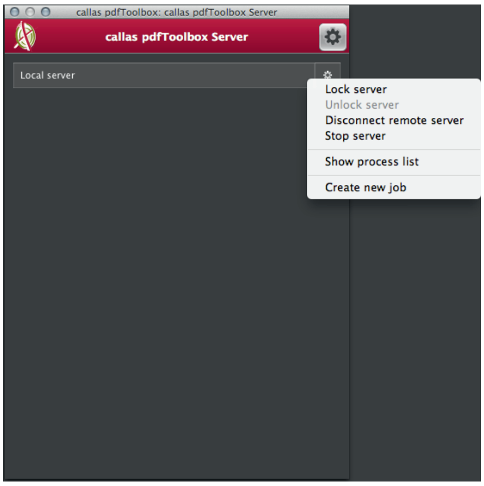
2.) Display all corrections that are present in the profile

In order to view all corrections that are present in the profile or in order to modify or add corrections, the profile can be opened in the profile editor. That is possible by clicking on the "edit…" button behind the name of the currently selected profile. All predefined profiles are locked and need to be unlocked in order to be edited. This is possible by using the pop up next to the profile name in the upper area of the dialogue. Then at the right hand side of the dialogue all editable parts of the profiles are listed and the "Fixups" part contains the corrections of this profile.

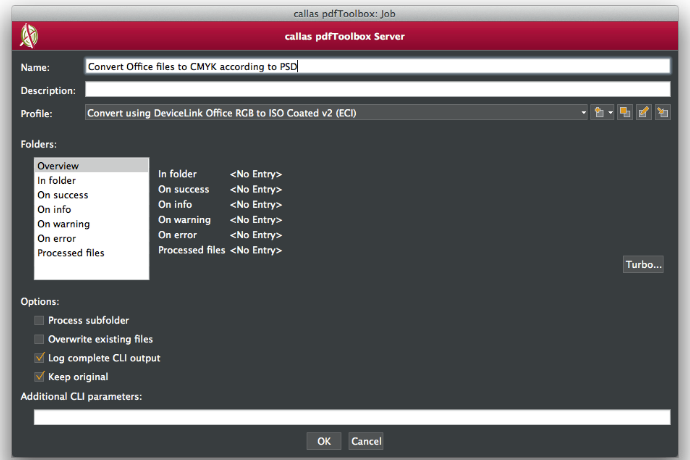
3.) Convert PDF file in hotfolder mode using pdfToolbox Server

In order to convert PDF files in hotfolder mode pdfToolbox Server needs to be installed and activated. If that is the case pdfToolbox Desktop has a "Server" entry in the Tools menu. If it is used the server window opens and a server can be started. After that the options menu behind the server entry allows the user to create a new job.





The next dialogue folders for hotfolder processing are to be defined and the profile for the job needs to be selected. In the Profile popup it is again possible to filter for profile names that use "office". After saving the new job it can be started by clicking on the "Play" button behind the profile name.



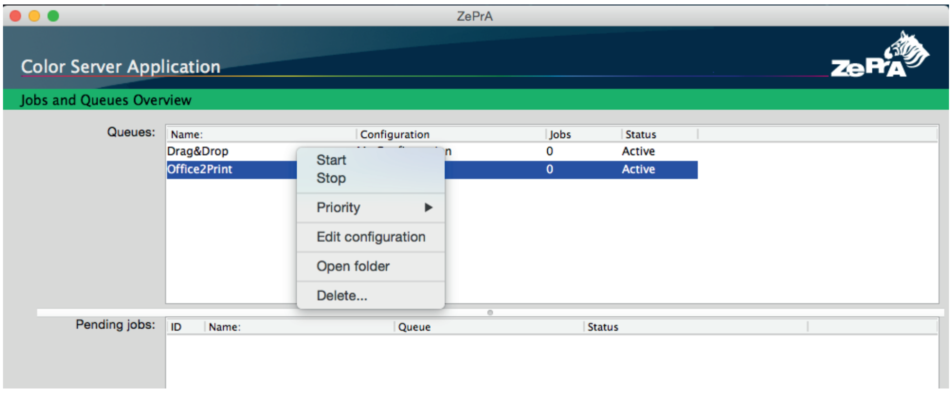
3.5.2 Practical use case: Company Color Logic GmbH

1.) Requirements for converting office generated PDF files with ColorLogic ZePrA

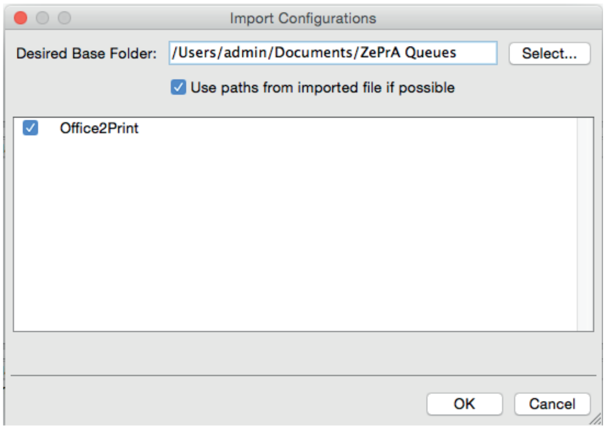
To utilize the configuration, please download ColorLogic ZePrA (version 4.1.3 or later from here: https://colorlogic.de/en/zepra/) including a **SmartLink** license (ZePrA L license or above). Please install and activate the license in the **Registration** window. The configuration used in this description can be downloaded for free from the Fogra website (https://fogra.org/en/downloads/work-tools/processstandard-digital-psd).

2.) Import a configuration in ZePrA

Launch ZePrA choose **Import configuration** in the **Tools** menu.



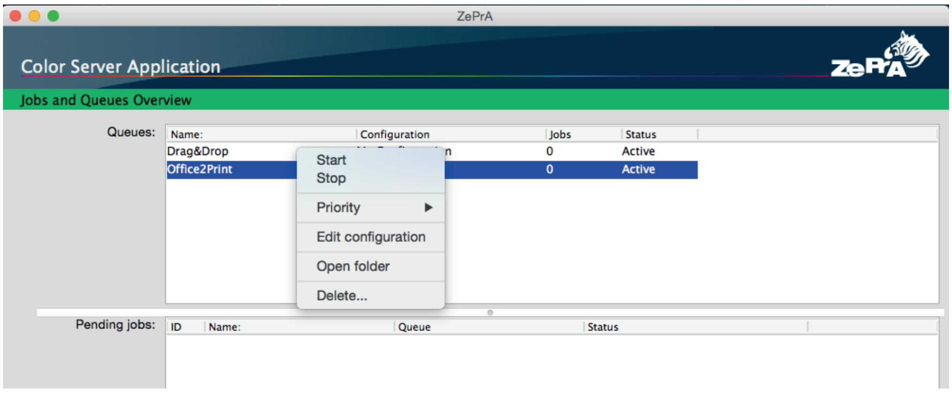
Navigate through the normal dialog on your system, select and choose the configuration file (Office2Print.ccf). After clicking **Open**, the second dialog box will confirm the **Configuration** that was chosen.



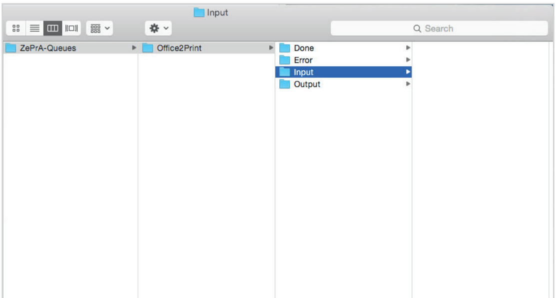
After clicking **OK** all hotfolders will be created in the default user directory. To customize the location of the hotfolders, choose **Select** for the appropriate directory to be selected.

3.) Converting data to CMYK

In the main window, a new entry will be added to the **Queue** section. Select the **Queue**, right click and choose **Open Folder**. ZePrA will automatically open the **Input** hot folder.



Copy the file to be converted to the **Input** folder and ZePrA will automatically process the file. The file will appear under pending jobs and show the progress of completion. The processed file can be found in the **Output** folder. The original file is moved to the **Done** folder.



Power user tip: Drag-and-drop files directly to the specific **Queue** in ZePrA's **Main Window.** The processed file will appear in the same folder of the original file.

4.) Specifics of the ZePrA configuration

This ZePrA configuration demonstrates how all color conversion are handled dynamically and respects all embedded ICC profiles. The **SmartLink** module ensures that similar RGB values (DeviceRGB or ICC based RGB) and gray objects (DeviceGray or ICC based Gray are converted automatically to K. CMYK objects with embedded profiles are converted with the **Preserve Separation** method that preserves the K channel.

This configuration allows the flexibility to be used in a variety of scenarios including the option to change the target profile with the output profile for a specific digital printer.

3.5.3 Practical use case: Company XXX

3.6 Migrating from FOGRA39 to FOGRA51

Never change a running system? – Yes, please do so!

FOGRA39 represents a well-known and established industry standard both for data exchange and commercial offset printing (on premium coated paper). The corresponding ICC-profile ISOCoated V2 - or ISOCoated V2 bas from basiccolor or CoatedFOGRA39" from Adobe – proofed to result in acceptable and state-of-the-art separations.

FOGRA51 - data separation and print conformance excellence

With the release of FOGRA51 and its corresponding ICC profile (PSO Coated V3) now a high level of colour communication while meeting rigorous colour tolerances can be achieved successfully. In order to allow a smooth migration from FOGRA39 to FOGRA51, some practical questions should be answered.

1.) How do I explain the change to non-print experts?

As with FOGRA51 all new Fogra standards are based on M1 ("real D50") and allow both, compliance with the latest ISO standards and a high quality of colour communication. Using FOGRA51, an outstanding proof to print match can be achieved. The FOGRA51 proofs serve as the colour reference interface for the colour dictator in different workflows.

2.) Do I need new measurement devices?

Following the principle "to measure as you see" each print shall be measured by using the same measurement condition that was used when creating the reference. Hence, for measuring FOGRA51 onwards, at least one device capable of M1-measurements needs to be present.

3.) Do I need new viewing cabinet?

You need an ISO 3664-2009 compliant viewing scenario to judge proofs and prints correctly. Only then you can be assured that the right amount of UV is present and the OBA in your proofs and production stock will be excited in the same way. Combining M1-measurement and M1-viewing allows for outstanding colour communication. This ensures predictability for the designer and the security for print service provider that an instrumental match also matches visually.

4.) How big is the difference between FOGRA39 (ISOcoated_v2) and FOGRA51 (PSOcoated_v3)?

Not big, indeed. The average colour difference is barely noticeable (ΔE_{00}=1,6). Depending on the image content it can be entirely possible that you need a closer look to tell them apart. The same applies for the data separation with both profiles, since the gamut mapping and separation parameters are very similar.

5.) As a designer, when and how do I change?

It is recommended to familiarize with the new profile as soon as possible. This means to download the profiles from the ECI-webpage and the recipes and preflight tools from the Fogra webpage. It also means to be able to create FOGRA51 based proofs either by updating your proofing hard- and software or by asking your proofing service provider. The details of how to implement and use the profile for image separation (in Photoshop) or layout conversion (in InDesign or Quark) can be found in this chapter. The paramount factor is the communication with your print partners! The rule of thumb is: If the printing condition is not precisely known upfront, use PSOCoated V3. If it is known, use the relevant Fogra standard. This idea is depicted in Fig. 3.20.

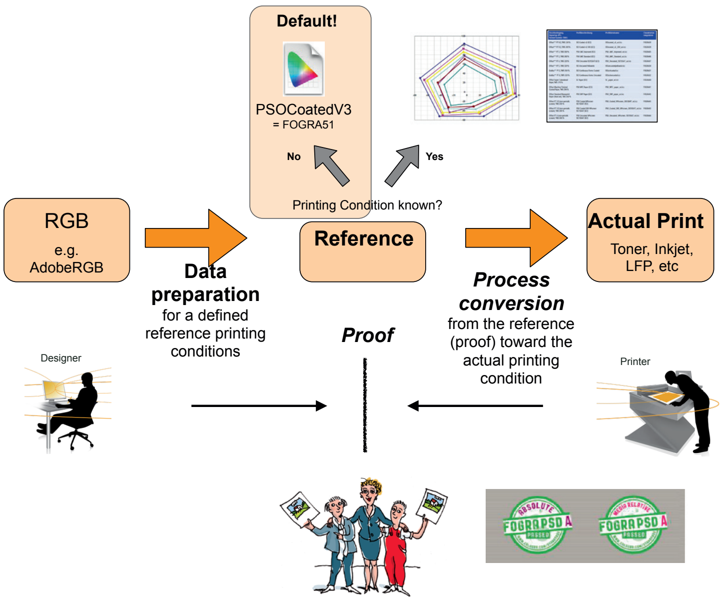
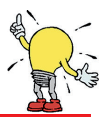


Fig. 3.20: How design and print work together. The key question is whether the final printing condition is known. If it is not (common practice), it is recommended to use PSOCoated V3. Otherwise use the pertinent Fogra standard. It is the print service provider's responsibility to consume the incoming data, normalize it and do the necessary process conversions (colour transformations). The contract proof or validation print serves as the reference between design and print.

6.) As a print service provider, when and how do I change?

It is recommend changing with the publication of the PSD 2016 handbook. Other than offset printers (who "only" have to adapt plate curves), digital printing service providers have to check normalisation and machine profiling. Normalisation refers to making the incoming data print-ready, hence PDF/X-1a (V.1) or X4 (V.2) with FOGRA51 as the output intent. Here the workflow tools need to be updated and unprofiled CMYK (as is) will now be interpreted as FOGRA51 and not FOGRA39 anymore. This includes updating the device link profiles. Machine profiling requires to characterize (profile) your machine combinations with M1. Incoming FOGRA39 artwork will be honoured by normalising it to FOGRA51 (e.g. by using the ECI FOGRA39-to-FOGRA51 device link profile). The quality of the normalisation can be tested by comparing the FOGRA39 proof of the original document with a FOGRA51 proof of the converted document.

Following the PSD principles ("Printing the expected") a print service provider is able to communicate colour in a professional way. It is recommended to proactively inform the print buyers & designers about the "new" Fogra standard. Show your colour competence!



HINT

The ECI device link profiles (FOGRA39-to-FOGRA51 and vice versa) can be found at http://www.eci.org/de/downloads

7.) Do I have to convert "old" FOGRA39-based (CMYK) data?
If you proof the FOGRA39 data for FOGRA51 and you are happy with the result... nothing has to change. For best results dedicated device link profiles are needed for the conversion, such as the free ECI profiles. The transformed data can then be compared with the original FOGRA39 proof to see how close the final result can be.

8.) Does a print shop need a colour server software (functionality)?
Yes! Orchestrating the plethora of incoming data requires a colour server that uses static or dynamic device link profiles. Picture by picture adjustments, e. g. made in Photoshop, are subject for niche applications with specific focuses.

9.) How about proofing?
All main proofing manufacturers offer FOGRA51 and FOGRA52 proofing setups. In particular, an OBA-rich proofing substrate should be used and an M1-based measurement device (either built-in such as the ILS30 from Epson or an external measurement device). For FOGRA52 proofs an OBA-rich substrates with a matte surface is recommended.

10.) How about print conformance?
There are many reasons for checking print quality on a regular basis. Either the print buyer requests a conformance protocol or your internal quality management policy expects quality tracking. In all cases, the PSD print check is the right solution. You can find the details in chapter 6. Please note the new 2018 tolerances for the "A, B, C-tolerance bands".

11.) Any other question?
Don't hesitate to use the Digital Printing Working Group mailing list at
http://lists.fogra.org/listinfo/dpwg

Update

3.7 Data preparation for multicolour printing ("jobs changes, inks don't")

Adding spot colours to existing CMYK, i.e. CMYK+X is gaining increasing popularity. The extended colour gamut (ECG) is typically used in two different situations:

- To improve the reproduction and brilliance of colourful RGB source images, typical in high-quality image photo printing
- To substitute spot inks for applications such as packaging printing and the typical workflow for the first use case is shown in Fig. 3.21.

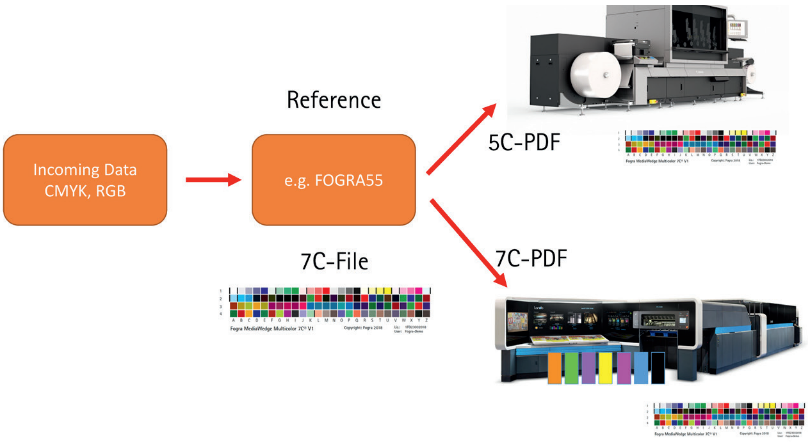


Fig. 3.21: Typical ECG-Photo workflow. Often wide gamut RGB data (Adobe RGB or eci-RGB v2) are being transformed to a large gamut exchange colour space such as FOGRA55. That can be proofed as a contract proof or a soft proof and it serves as the reference for the output on a wide gamut press. Here a colour server is required to convert from FOGRA55 to the actual CMYK+X press profile.

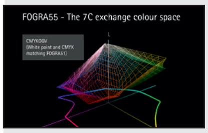
The image content is separated into the ECG reference printing condition. In case an individual, "ECG houseprofile" is present, this can be used. In most cases the use of a large gamut exchange colour space is recommended. For that purpose FOGRA55 was developed. It is based on CMYK as defined in ISO 12647-2:2014 for offset printing on premium coated substrate and the additional Orange, Green and Violet colours were picked to create a reasonable large and representative gamut. When designing FOGRA55 it was important that it can be proofed with commercially available digital proof printers within established tolerances.

The contract proof is of utmost importance since the current PDF imaging model does not support ECG. Therefore the rendering of ECG separated content within the Adobe authoring tools are not colour binding. Even worse they the rendering differs among Adobe Photoshop an InDesign. That limitations make the "ECG photo retouching workflow" quite specific – relevant mostly for expert users typically equipped with additional toolboxes that overcome the many roadblocks.

The use of FOGRA55 as a reference printing condition is also recommended when driving wide gamut presses directly. While a direct transform from the source RGB data to the actual press profile might lead to the optimum result, it was shown that using FOGRA55 "in between" improves both colour predictability and consistency. For instance different profile makers or profile maker settings might lead to pleasing prints for the time being but they lack any consistency over the time and over different locations.

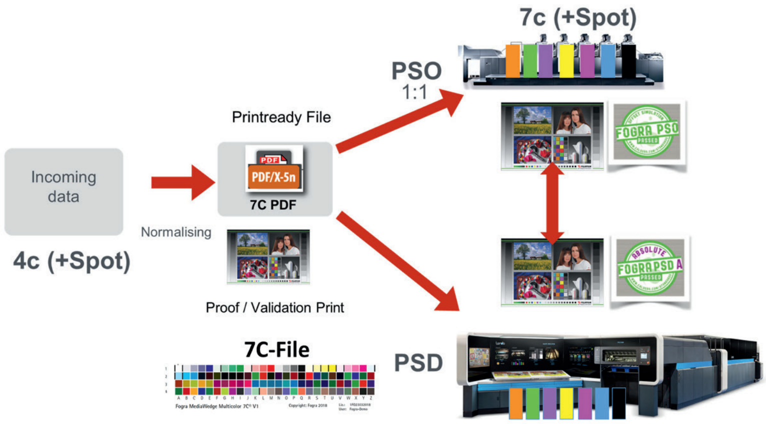
Hint:

For more Informatations see: https://fogra.org/en/research/prepress-technology/multiprimary-printing-13003



Update

Much more popular is the ECG packaging workflow, as shown in Fig. 3.22.
Here common "CMYK + spot" artwork is analysed with respect to available ECG scales (e.g. CMYKR, CMYKOG, CMYKOGV, CMYKRGB, etc.) in order to minimize spot colour errors. Such an ECG-report covers the best possible colour difference (ΔE00) per spot colour, which is the basis for routing the print job to a classic CMYK-spot press configuration or an ECG-press.



Tab. 3.2: Typical ECG-Packaging workflow. Often legacy CMYK data + spot colours are being preflighted and analysed with respect to the optimal ECG separation. When the decision is made in favour for ECG (instead of conventional CMYK + Spot) the print data is separated for the actual ECG printing condition; here a CMYKOGV offset or digital press.

Hint:
For more Informations see: https://www.taga.org/2021-presentations/

For ECG print or proof evaluation it is important that the Fogra MediaWedge Multicolor is assigned to the print data after being transformed to the ECG reference printing condition, e.g. CMYKOGV for FOGRA55. At this point it is important to name the colour channels consistenly.

4 Image Appraisal

4.1 Practical tips for image appraisal

Introduction

In day to day production prints are often appraised under daylight, because daylight is well suited to judge colours. In addition this practice also reflects a typical viewing condition of the recipient of the print. Especially the image appraisal close to a north side window has proven to be useful, because the mostly diffuse light there results in a uniform illumination. But depending on daytime, weather or location the daylight spectra will change significantly. Last but not least there is no daylight in the late evening or during the night. Therefore a standardized illumination, so called norm light is needed to assure that colour communication can be of high quality and consistent. The poet and "colour scientist" Goethe the states "Colours are results and bearings of light" („Farben sind Taten des Lichts, Taten und Leiden"[1]). For this reason for colour critical appraisal of prints light technical parameters influencing the light have to be considered – especially when different locations are involved. These parameters will be discussed in this chapter. Further parameters to take into account when planning and realizing an appropriate lighting situation like energy or ergonomics are not discussed in detail here (see figure 4.1)

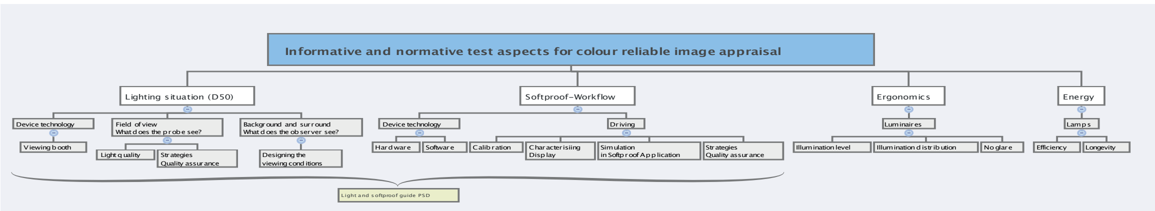


Fig. 4.1: Outline of the parameters discussed in this chapter to achieve a colour correct image appraisal.

There are many different uses of a norm light and as well varying user demands. To allow to fit an individual solution for a norm light informative and normative criteria are given here. They include setup, operation and quality assurance. The test criteria are presented in a structured, tabulated form. If a test criterion cannot be applied to a test category this is denoted with n.a. for "not available".

The normative criteria are indispensable to achieve a high common industrial quality. They are described as a prerequisite of a PSD certification. The informative criteria are nevertheless as well important. Those criteria are given informative because of a potential complexity where currently no objective criteria have been elaborated or are too hard to check to justify them to be characterized as a normative criterion. All criteria given here should be checked independent of a PSD certification.

The list of test criteria is complemented by an additional table with corresponding test methods, tolerances or potential suggestions for improvement.

Increasingly softproofing systems are used in the graphics art industry. For a softproofing-system – most often including a norm light – it is needed to add use case specific criteria. They are described at the end of this chapter.

The focus of the practice recommendations presented here lies on the appraisal of a physical sample, e.g. the comparison between a print and the OK-sheet or a proof print or the

1 Johann Wolfgang v. Goethe, Zur Farbenlehre (Preface), 1810

reproduction of a soft-proof. The colour accurate appraisal of a file displayed solely on a monitor, for example for colour grading of an RGB file, is not discussed here. Although the colour accuracy in such a case can be improved significantly when following the guidelines presented. In addition to the criteria listed in this chapter you find further practical guidelines and background to setup a softproof system in the Fogra Softproof Handbook.

Lighting situation

The purpose of a viewing booth is to allow the same colour appearance when judging prints (that means object colours) at different locations and / or times. The norm light serves as a stable reference for colour critical image appraisal.
The requirements for a viewing booth are worldwide similar. To address the needs of the graphics arts industry and finally to scrutinize viewing booths ISO 3664 was elaborated. This standard gives certainty for manufacturers as well as users to evaluate a standardized viewing booth – therefore also called norm light.
To assess the lighting situation comprehensively (regarding the D50 illuminant) in the printing industry a structure is suggested as follows:

- 1. Device technology, this means viewing booth in this context
- 2. Irradiation ("what does the sample 'see' / what has influence on the sample?") and
- 3. Viewing conditions including background and surround ("What is seen by the observer?").

First informative and normative criteria for the viewing booth are presented. Then parameters influencing the irradiance, resulting in a certain colour rendering in the viewing plane where the print is appraised – are considered (-> Lighting quality)
Assessing the light in the viewing plane answers the question which direct or indirect light has influence on the colour rendering. This influence can be either positive – resulting in a defined colour appearance or can be negative – resulting in inhomogeneities or even glare.
After a first-time test of the light situation it is important to establish means for a regular quality assurance. Related ideas are also suggested.
Surround and background will have impact on the colour perception of an observer. In a last step criteria to assess the objects in the viewing field are given.

Prerequisites of the device – viewing booth

In front of an individual and detailed inspection of a viewing booth the following criteria can be evaluated easily following the check list. In this tabulated list – as well as the following tables – a test number is assigned to each test criterion. For each criterion it is stated if this will be evaluated normative or informative

Test Category	Test No.	Criterion	Normative	Informative
Conformance to ISO standard	1a	ISO 3664 Certification / valid for viewing condition P1	√	
	1b	If a softproof system is tested:	√	
Viewing booth features	1c	ISO 3664 Certification / valid for viewing condition P2	√	
Information	1d	Journal with details regarding a) run time lamp b) type of cabinet		√
Test options	1e	Measuring device for illumination measurements		√

Tab. 4.1: Criteria to check a viewing booth prior an individual test on location.

Assessment at the viewing plane

After the basic suitability of the viewing booth was tested in the prior step the irradiance has to be evaluated by measuring the spectral power distribution in the viewing plane. If a viewing booth is designed to appraise three-dimensional objects the following criteria have to be applied in sample locations in the space in addition to the viewing plane.
To assure the high quality of the viewing booth regular quality tests are needed. Normative and in-formative criteria are listed for both aspects.

Test of illumination

The direct light of the viewing booth and any light from other light source like ambient room light or day light result in a combined spectrum in the viewing plane. The measurement of the spectral power distribution allows to conclude if light not originating from the viewing booth falling on the sample will have a significant (often negative) influence. If this is true optimization can be derived after evaluating the informative criteria.

Test Category	Test No.	Criterion	Normative	Informative
Room- and Viewing booth lighting	2a	No direct day light in viewing plane	√	
	2b	No influence of coloured objects (e.g. walls, ceiling, big plants etc.) in the viewing plane		√
	2c	I luminance measurement and conformance check regarding ISO 3664 criteria		√
	2d	Assessment UV-radiation: MIuv		√

Tab. 4.2: Criteria to assess the irradiation, "spectral finger print" of a viewing booth in the viewing plane.

Means for quality assurance in day to day production

A high quality can be maintained when regular quality tests are established.

Test Category	Test No.	Criterion	Normative	Informa-tive
Conformance to ISO standard	3a	Regular (at least every 3 months) illumination measurement and comparison to the results achieved after installation and conformance check to ISO 3664 tolerances		√
Visual test	3b	Metameric test, e.g. using composed grey [bvdm Graycon] Comparison proof print and (reference) print		√
Documentation	3c	Journal (log) of all test results		√

Tab. 4.3: Criteria for regular quality test of the illumination at the viewing plane.

Judging background and surround

When visually appraising an object, e.˘g. the proof print, the observer also will see the direct back-ground of the object displayed. Typically this will be the surface of the table in the norm light. Every-thing in the field of view besides the background is called 'surround'. In a big viewing cabinet with side walls the main or complete surround will consist of the back plane and the side walls itself. In a smaller or open type viewing cabinet the surround will consist of near or close distance objects in the field of view. This can be a web-offset printing machine in a mostly dark room or a window front for example. Background and surround have a significant influence on the colour perception of the ob-server. The field of view can be objectively evaluated with the help of a photo from the point of view (the aperture angle of the lens has to match the angle of the eye). A grey card and / or a calibration target for cameras will serve as the needed reference to estimate trichromatic values deduced from the RGB data.

Designing the viewing conditions

Test Category	Test No.	Criterion	Normative	Informa-tive
Glare (Dazzle)	4a	No direct glare induced by light sources	√	
	4b	No glare induced by reflections in the field of view from mirroring objects	√	
Colour	4c	Low chroma background and surround		√

Tab. 4.4: Criteria to test the background and surround in the field of view. Objects with high chroma as well as high contrast influence the colour appearance and are therefore to be avoided

Use case specific design of viewing condition

This section adds specific tips to test the norm light setup and possible strategies to improve a criterion.

Viewing booth

Test Category	Test No.	Tips for approvement	Test method / tolerance
Conformance to ISO standard	1a und 1b	Demand ISO 3664 certificate from the vendor or assign one. (See e.g. https://fogra.org/en/certification/prepress-technology/viewing-conditions)	n.a.
Viewing booth features	1c	Retrofit a dimming option or new acquisition of a dimmable viewing booth	n.a.
Information	1d	Buy a journal or create a log file, e.g. in a spread sheet program.	n.a.
Test options	1e	Buy a spectro-radiometer or colorimeter suited for light measurements	n.a.

Tab. 4.5: Possible strategies to improve the performance of a viewing booth (cabinet)

Judging the viewing conditions of the viewing level

Test Category	Test No.	Tips for approvement	Test method / tolerance
Room- and Viewing booth lighting	2a and 2b	Install anti-glare device, e.g. (sun) blinds	Visual check: Turn off the viewing cabinet. From the viewing point no direct light source (lamp or sun) and no indirect light source (mirror or mirroring surface) is visible.
	2b, 2c and 2d	1) Avoiding unwanted influence of room lighting: a) List all variable light sources which can be change easily: Windows, Shiners b) List all installed light sources: ceiling lighting, viewing cabinet c) Switch room lighting to D50 near light 2) Improve D50 spectra of the viewing cabinet a) Check reflectors, diffsors and lamps in the viewing cabinet and replace as needed. Consult the manufacturer for details.	Metrological test: Check for ISO3664-compliance, e.g. with Excel-File (see Fogra Website) under practical use. This means to measure the light of the viewing booth and potentially existing room light. Note Ra, Ri, CIEuv, MIvis, (and MIuv). In addition measure the light of the viewing booth without influence of room lighting if possible. Comparing both measurements will show if room light has significant influence on the viewing booth light.

Tab. 4.6: Details for visual and metrological tests of the irradiance in the viewing plane. Potential tips for improvement of a specific criterion is given. Note: MIuv can not be evaluated with most hand-held devices used in the graphics art industry, when the UV con-tent between 300 and 380 nm is not included

Means for quality assurance in day to day production

Test Category	Test No.	Tips for approvement	Test method / tolerance
Conformance to ISO standard	3a		Metrological test: Check for ISO3664-conformance, e.g. estimate with a hand-held device and Excel-table, see Fogra-website: https://fogra.org/en/downloads/work-tools/softproof-lighting
Visual test	3b	n. a.	Visual test: Metameric test, e.g. with different-composed greys of the same CIELAB value. Comparison of (reference) print and matching proof print. For optimal results create a custom ICC profile for the (reference) print as a basis for the proof print.

Tab. 4.7: Test details for visual and metrological quality assurance over time.

Designing the viewing conditions

Test Category	Test No.	Tips for approvement	Test method / tolerance
(Discomfort) Glare	4a and 4b	1) List all variable light sources: Windows, shiners, blinds 2) List all installed light sources ceiling lights, viewing cabinet 3) Install anti-glare device, e. g. (sun) blinds, sun visor, movable walls 4) Optimise shiner positions	Visual test: From the viewing plane no deranging direct light source (shiner, sun) and no indirect light source (mirroring surface) is visible.
Colour	4c	List all coloured objects in the viewing field (e. g. walls, ceiling, big plants etc.	n. a.

Tab. 4.8: Details for visual tests of the viewing conditions and potential improvements.

4.2 Practical tips for Softproofing

This section builds on the practice tips for viewing cabinets. The criteria presented here must therefore be taken into account in addition. The additional criteria covered for softproofing systems include the choice, setup and operation.

Softproof workflow

More and more softproof systems are used to save time and cost – partially replacing or supplementing hard copy proof prints. Current softproof systems achieve colour accuracy similar to contract proof systems. This is the case when hardware and software components fulfil specific requirements. Based on the actual system an appropriate driving has to be established. This includes in determining the calibration target values, characterizing the display and suited use of the softproofing application.
Last but not least the high colour accuracy of a softproof system can be only achieved with proper maintenance and quality assurance, e. g. by validating the monitor calibration. In the following the term 'monitor' is used when the hardware aspect is emphasized. In contrast the term 'display' is used when the main focus is on the visual result of the softproof.
Initially normative and informative criteria to achieve the wanted high quality level are presented. Following hints and tips are given to each criterion and potential ways for improvement are given.
Currently there are no criteria established to conclude if a softproof is colour reliable in the same sense like a contract proof. Scientific and practical foundations are worked out in a Fogra research project.

Judging device technology

The following criteria can be checked easily. Those criteria list the basic features and capabilities a monitor has to deliver to become vital part of a softproofing system.

Hardware

Test Category	Test No.	Criterion	Normative	Informative
Monitor controls	5a	Luminance	√	
	5b	White point: RGB adjustment possible	√	
	5c	Gradation adjustment		√
Monitor features	5d	Driving ≥ 8-Bit (continuous)	√	
	5e	Digital connection (e.g. DVI, DisplayPort, HDMI)		√
	5f	Display 1:1 possible, e.g. 21"-Monitor with a resolution of 1600 x 1200, to display 2 A4-Sheets in portrait format		√
	5g	Monitor measurement device and -software	√	
	5h	Monitor shield		√
	5i	Up-to-date calibration certificate for monitor measuring device		√
	5j	Tele-measurement device		√

Test Category	Test No.	Criterion	Normative	Informa-tive
Display properties	5k	(semi-) matte screen surface	√	
	5l	Uniformity: Criteria FograCert Softproof Monitor	√	
	5m	Viewing angle: IPS- or VA panel type* or Monitor PreCert (FograCert Softproofing System)	√	
Test pictures	5n	Reference print, e.g. contract proof for visual fine tuning and test	√	

*Tab. 4.9: Criteria to test the fundamental suitability of monitor for softproofing system. *When new panel types will be usable and available (e. g. OLED) the list will be updated accordingly.*

Software

Test Category	Test No.	Criterion	Normative	Informa-tive
Validation options	6a	Characterization	√	
	6b	Calibration		√
	6c	Apply device specific calibration data (if used for calibration)	√	
	6d	Colour difference formula: ΔE00		√
Test pictures	6e	File for reference print	√	
Monitor desktop	6f	Grey desktop background or desktop test picture (e.g. Fogra desktop background)		√

Tab. 4.10: Criteria to test the fundamental suitability of calibration software, softproof application and operating system.

Assessment of monitor driving

The monitor driving is comprised of the optional calibration to specific target values, characterization of the display and determining the colour values to be displayed in the softproof application. Today most softproofing systems use an approach where the monitor is calibrated to target values (often by means of a so called hardware calibration). This allows a straight forward and in portions standardized characterization of the display. In such a softproofing system the target luminance, white point and gradation are often chosen according to some 'standard' values. Those target values are used directly or might be basis for visually motivated derived target values.

The calibration and characterization accuracy can be tested easily with a handheld measuring device.

Calibration of the monitor

Test Category	Test No.	Criterion	Normative	Informa-tive
Identifying target values	7a	target values for photographers workflow without a viewing cabinet		√
	7b	target values for creation or print work-flows		√
Calibration	7c	High calibration accuracy for white point, luminance and gradation		√
Calibration result of display	7d	Visual assessment: Smooth rendering of grey ramps (native without colour management and in soft-proof application) Details in lights and shadows (in soft-proof application) Uniformity (if calibration has influence)		√

Tab. 4.11: Criteria to test the (optional) monitor calibration.

Characterizing the displayed image

Test Category	Test No.	Criterion	Normative	Informa-tive
Profile accuracy	8a	Average colour difference between CIELAB value determined from the ICC-profile and the relevant measuring value	√	
	8b	99 % -quantile or maximum colour difference between CIELAB value de-termined from the ICC-profile and the relevant measuring value*	√	

Tab. 4.12: Criteria to test the accuracy of the display characterization (mostly by means of ICC monitor profiles).
**: If there is no option to calculate the 99 % quantile the maximum can be evaluated.*

Simulation within the softproof application

A metrological test of the monitor calibration and characterization is a prerequisite to achieve a colour accurate softproof. But the final visual result in the softproof application is crucial. Therefore in the FograCert Softproofing System this is tested objectively with the help of a laboratory tele-spectroradiometer. Instead in day to day production a visual test comes in handy. A visual test cannot be reproduced as easily like a metrological test, but nevertheless a visual assessment can be of great help for the individual operating a softproofing system.

Test Category	Test No.	Criterion	Normative	Informa-tive
Workflow	9a	Correct setup of the softproof workflow, either remote softproof or for data crea-tion (e.g. Adobe Photoshop)		√
	9b	List file formats, e.g. PDF, Tiff		√
Visual test	9c	Good visual match of (proof) print and according softproof (normally with the relevant ICC profile)		√

Tab. 4.13: Criteria to test the practical softproof result.

Matching (proof) print under norm light and softproof

Test Category	Test No.	Criterion	Normative	Informative
Workflow	10a	D50-similar room lighting		√
	10b	Visually motivated dimming of the norm light		√

Tab. 4.14: Further criteria to test the practical softproof results.

Strategies and means for quality assurance

To assure a stable softproofing system regular controls are needed. Important criteria are listed in the following table.

Test Category	Test No.	Criterion	Normative	Informative
Metrological (objective) test	11a	Regular (at least monthly):	√	
	11b	Validate display characterization	√	
	11c	Target luminance reached?		√
	11d	Validate calibration		√
Visual test	11e	Regular (at least monthly):	√	
Calibration result monitor	11f	Visual assessment: Smooth rendering of grey ramps (native without colour management and in softproof application) Details in lights and shadows (in softproof application) Uniformity (if calibration has influence)	√	
Documentation	11g	Journal (of normative test results	√	
	11h	Journal of informative test results		√

Tab. 4.15: Quality assurance: Criteria for regular checks of the light quality in the viewing plane.

Test details and possible ways to improve the setup

This section adds specific tips to test the softproof system and possible strategies to improve a criterion.

Hardware

Test Category	Test No.	Tips for improvement	Test method / tolerance
Monitor controls	5a and 5b und 5c	The monitor luminance and white point have to be controlled via the On-Screen-Display (OSD) and / or by means of a hardware calibration with suited software. If gradation (~ 'gamma') is calibrated it is of advantage if this can be also controlled hard-ware wise. If a monitor offers fewer controls the more likely a so called software calibration can result in visible banding – seen in data wise smooth gradients. Laptop displays are therefore normally not suited for color critical work. In addition often the viewing angle and gamut will lack. If white point and luminance cannot be controlled hardware wise switching the monitor might be advisable (see : https://fogra.org/en/certification/prepress-technology/softproof-monitor).	n.a.

Test Category	Test No.	Tips for improvement	Test method / tolerance
Monitor features	5d and 5e	The monitor has to offer a digital connection with at least 8 Bits / channel for panel, interface and video graphics card. This assures a stable connection over time as well the needed colour resolution (e.g. for gradients). If not applicable the monitor has to be exchanged for another model.	n.a.
	5f	A 1:1 view should be possible. Therefore a mini-mum size of 21" (with 1600 x 1200 resolution) allows to display 2 A4 sheets portrait mode in original size is often recommended.	Measure display size or calculate from known screen resolution and diagonal
	5g	Monitor measuring device and software have to be available. Colorimeters often have advantages in the shadows, but can greatly benefit from a monitor specific calibration. Spetroradiometers normally do not rely on a device specific calibration.	n.a.
	5h	A monitor shield minimizes contrast reduction (especially in shadows) and should be used in general.	n.a.
	5i	To assure the function of the monitor measuring device it is recommended to follow the manufacturer's recommendation for maintenance (normally once a year). Measuring devices not part of a maintenance program from the vendor should be compared regularly to devices maintained. If results drift away over time exchange the non-maintained device. Tips for day to day checks are subject of the current Fogra research project 10.056..	n.a.
	5j	To assess the possible contrast reduction caused by room lighting it is helpful to use a tele measurement device. If a distance-measurement device is not available the influence of the room lighting can be estimated with the help of a light measurement and of the reflection of the dark-screen-display and a contact measurement of the softproof colour. An excel file is available on the Fogra website	n.a.
Display properties	5k	A semi matte screen surface is necessary to avoid interfering reflections from the room lighting for the softproof.	n.a.

Test Category	Test No.	Tips for improvement	Test method / tolerance
	5l	A monitor has to fulfil the FograCert uniformity criteria (see https://fogra.org/en/downloads/work-tools/softproof-lighting). Unfortunately currently there is no software available to assess those criteria from an end user's side. The Fogra website lists all monitors which passed this aspect of the FograCert Softproofing System certification: https://fogra.org/en/certification/certified-persons-companies-and-products/softproof-monitor	n. a.
	5m	Displays with an IPS or VA type panel* (and similar subtypes like P-IPS, PVA or with different names) fulfil high demands in regards of viewing angle characteristics. The Fogra website lists all monitors which passed this aspect of the FograCert Soft-proofing System certification: https://fogra.org/en/certification/certified-persons-companies-and-products/softproof-monitor The viewing angle characteristics can be judged with high validity by means of visual test pictures avail-able free from the Fogra website: https://fogra.org/en/downloads/work-tools/softproof-lighting	n. a.
Test images	5n	To test the softproof quality visually a reference print has to be available which can also be used for a potential visual fine-tuning.	n. a.

*Tab. 4.16: Criteria to test the fundamental suitability of a monitor used in a softproofing system. *When new panel types will be usable and available (e. g. OLED) the list will be updated accordingly.*

Software

Test Category	Test No.	Tips for approvement	Test method / tolerance
Validation options	6a and 6b	The calibration software shall allow testing the characterization accuracy (ICC profile accuracy) and should allow testing calibration accuracy if applicable (luminance, white point, gradation).	n. a.
	6c	The validation has to make use of device specific corrected measurement data, if the calibration uses device specific calibration routines. Normally this condition is met when the vendor offers a validation in the calibration software itself. External tools (e.g. UDACT) normally cannot guarantee correct results in this case. Therefore external validation tools can only be used if no device specific calibration is used!	n. a.
	6d	The colour difference of validation tools should be calculated with the modern colour difference formula ΔE00 because this will result in a high correlation of visual and measured results. This formula is also used for the FograCert Softproofing System.	n. a.
Test pictures	6e	The file for the reference print has to be available. To achieve the closest possible match of softproof and reference print a custom ICC profile for the used reference print is best. This is not needed when the reference print is very accurate, like a high quality (~ half tolerances for media wedge) contract proof.	n. a.
Monitor desktop	6f	A grey desktop background or test pictures (e.g. Fogra desktop background) serves as a neutral adaption point for the observer. See https://fogra.org/en/downloads/work-tools/softproof-lighting	n. a.

Tab. 4.17: Criteria to test the fundamental suitability of calibration software, softproof application and operating systems.

Monitor calibration

Test Category	Test No.	Tips for approvement	Test method / tolerance
Identifying target values	7a	Photographers workflow without the use of a viewing cabinet: Colour temperature: 5000 K – 6500 K, Gradation: 1,8 – 2,4 or L* or sRGB, Luminance: 'appropriate' for the ambient illumination	n. a.
	7b	Creation or print workflows: 1) Calibration to default values Colour temperature: 5000 K Gradation: matching to the most used colour working space Luminance: Illuminance in viewing plane / Pi => 500 Lux (Viewing Condition P2, ISO 3664) ~ 160 cd/m² 2) optional visual motivated optimization of the target white point (e.g. Compare [simulated] substrate white point in soft-proof to the print => Target definition: CIExy) and / or luminance Important note: A visual fine-adjustment is often needed for highest quality results for an individual observer should not be considered a flaw.	n. a.
Calibration	7c	The calibration accuracy for white point, lumi-nance and gradation should be better than ΔE00 = 3. If this information is not available as a rule of thumb a white point should be inside ± 200 K, luminance inside ± 5 % and gamma (gradation) of ± 0,15.	n. a.
Calibration result	7d	Visual assessment: Smooth rendering of grey ramps (native without colour management and in soft-proof application) Details in lights and shadows (in soft-proof application) Uniformity (if calibration has influence) Different calibration options (number of test colours, algorithms chosen) can have influence on the result – contact the vendor for system specific advice.	n. a.

Tab. 4.18: Criteria to test the (optional) monitor calibration.

Characterizing the display

Test Category	Test No.	Tips for approvement	Test method / tolerance
Profile accuracy	8a	Possible optimization: 1) different profile type: matrix/TRC or LUT-profile 2) other / more test colours 3) Maintenance / Exchange measuring device	Mean ΔE00 ≤ 2
	8b		99 % - quantile ΔE00 ≤ 4 or maximum ΔE00 ≤ 6*

Tab. 4.19: Criteria to test the accuracy of the display characterization (mostly by means of ICC monitor profiles.
**:If there is no option to calculate the 99% quantile the maximum can be evaluated.*

Simulation in the softproof application

Test Category	Test No.	Tips for approvement	Test method / tolerance
Workflow	9a 9b	1) Follow vendor specific advice / hand books 2) Attend seminars 3) Individual workflow consultancy	n. a.
Visual Check	9c		

Tab. 4.20: Criteria to test the practical softproof results.

Matching (proof) print under norm light and softproof

Test Category	Test No.	Tips for approvement	Test method / tolerance
Workflow	10a	Exchange or installation of new cabinets (luminaires) or lamps	ISO3664 check as estimation with handheld device (see Excel pro-gram at Fogra website)
	10b	Compare brightness of soft-proof and reference (proof) print displayed in the norm light -> Adjust dim level of norm light and / or luminance of the monitor	n. a.

Tab. 4.21: Further criteria to test the practical softproof results

Strategies for quality assurance

Test Category	Test No.	Tips for approvement	Test method / tolerance
Objective checks	11a 11b 11c 11d	1) Use reminder function in calibration or soft-proof application 2) Use extra calendar to remember test dates (recurrence function)	n. a.
Visual test	11e	If match of softproof and print is inad-equate check: 1) Measurement device 2) Monitor calibration 3) Software settings	n. a.
Calibration result monitor	11f	If gradients are not displayed smooth: 1) Check measurement device 2) Hardware calibration allows smooth renderings 3) In softproof applications slight band-ings can be caused by round-off-errors. In some calibration solutions the shadow details can be be influenced by choosing different options. A good compromise of a neutral and the achievable darkest colour has to be found.	n. a.
Documentation	11g 11h	Create written journal or documentation file (e. g. in a spreadsheet)	n. a.

Tab. 4.22: Quality assurance: Criteria for regular checks of the light quality in the viewing plane.

5 Process Control

5.1 General schema for process control

Contrary to offset printing there is no unified number or sequence of process control steps for common process control in digital printing. This is due to the plethora of different media, imaging technologies and inks to be used. Therefore the PSD provides general principles that can be used and applied for basically all digital printing processes. The following paragraph provides detailed recommendations and guidelines for all eight process steps. Here the Fogra softproofing handbook serves as a successful role model. It provides a general, vendor- and technology neutral schema, hence allows manufacturer to provide their practical solutions ordered by means of the aforementioned structure. This hierarchical schema is depicted in Fig. 5.1.

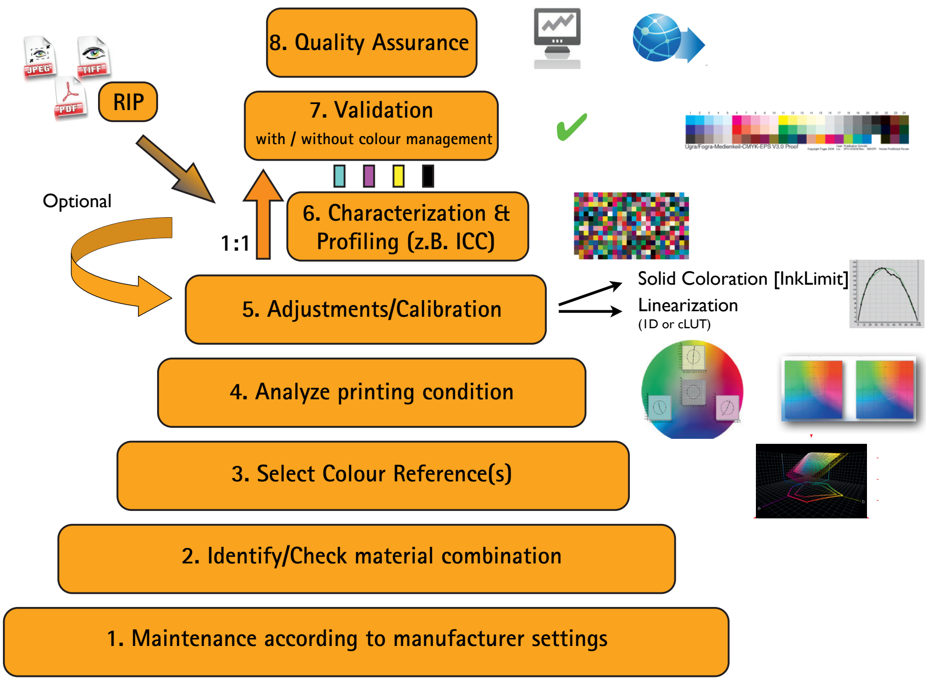


Fig. 5.1: General principles for process control for CMYK-based digital printing processes.

Step 1: Maintenance according to manufacturer settings:

At the very beginning it is critical for a successful workflow to operate according to a set of maintenance routines provided by the manufacturer of the printing machine. It calibrates machine sensors and components and brings the print engine back to centre. That includes both the consumables and the provided colour maintenance routines. The colour maintenance tools might be optimized for certain stocks. Depending upon print volume, the inherent printing system stability and the colour criticality of the customer, it is recommended that you perform a colour maintenance check no less than once daily, usually at the beginning of each shift. Colour and print volume requirements may necessitate more frequent colour maintenance. Usage frequency and incorporation of the maintenance tools into the print service providers daily workflow must be tailored by the requirements and the colour-criticality of your jobs. Colour maintenance tool activities and routines cannot be considered a replacement for visual inspection of jobs for image- and colour-quality problems.

Step 2: Identify / Check material combination:

The next step covers the selection of an appropriate substrate and the setup of a chosen paper for the given printing machine. Here physical limitations play a fundamental role regarding printability and runability. While printability mainly refers to a permanent (durable) colorant layer on (with the right inking level) the substrate, runability is related to the substrate being able to move through a printing path at production speed in a reliable fashion. After successful completion of printability and runability a fine tuning of the available parameter needs to be taken into consideration. Such parameters are the mechanical corrections for offset and mis-registrations, required printing speeds, the mass per area of the substrate, the elasticity (e.g. for soft signage) or the print mode - just to name a few. Errors quite often relate to not properly set up media databases.

Hint:
The media manager connects each substrate with a number of important parameters such as screening, ink load, ink split or the print mode. Since they lead to different colour responses, it is extremely important to carefully select and honour them.

Sometimes test prints are required where just the parameter of interest will be altered to find the optimal parameter combination. When performing test prints it is recommended to separate between engine-oriented (controller) and RIP-oriented (software) driving. The first is mostly provided by the manufacturer and controlled via the digital front end. A typical example is the nozzle check or head alignment of an inkjet printer or a gradation adjustment (e.g. by means of a built in densitometer) of a electrophotographic printer.
RIP-based driving relates to settings that are determined upstream via the driver or other control panels (e.g. Fiery, Creo or FFPS). Here individual test forms such as the Fogra image quality test form can be used. In order to test the influences caused by printing and not colour management it is important to use the device mode instead of the simulation mode. That is often known as "ColourManagement OFF" or "None".
In particular for xerographic systems it is common practice to link substrates (in combination with the established parameter set) with print related aim values (e.g. densities). Using and achieving these aim values (in combination with the associated measuring condition, which often uses UV-Cut filter) is usually a very good starting point to establish an individual printing condition. However it can be necessary to alter this predefined (default) aim values, see step 5.

Hint:
Device mode and simulation mode are explained in section 3.

In addition it should be noted that it is not reasonable to characterize all stocks in this fashion. Here it is important to group similar types of substrates that share basic print characteristics. An exemplary grouping can be done by separating coated from uncoated substrates.

Step 3: Select colour reference(s):

The third step is directly related to the previous one since the selected substrate directly impacts the gamut of the final print product, see 1.3. Before starting the following steps it is important to consider the typical reference printing condition (gamut) to be simulated. The same applies for the spot colours to be covered with a given printing condition. An overview of typical exchange space is listed in chapter 3.2. When no concrete printing condition is defined it is industrial typical to assume FOGRA51, i.e. printing according to ISO 12647-2 on coated stock. FOGRA51 or the related ICC profile PSOCoated V3 (ECI) can be considered as the de-facto reference for digital printers - not only in Europe.

Hint:
A CIELAB 1976 colour difference of $\Delta E^*_{ab} > 10$ can be used as an indication for large difference between the reference and the actual gamut.

Step 4: Analyze printing condition:

As soon as a reference printing condition is known it is now important to achieve it as good as possible. First the default solid coloration will be checked as to how close the reference primary and secondary colours can be met. Tolerance values might help to estimate how close the shell of the gamut - from paper white to the shadow region - can be hit with the chosen system combination, i.e. the actual printing condition. Analyzing an actual printing condition covers also additional aspects such as:

- Visual check of consistent and smooth vignettes -> used to select a suitable print mode and the (re-)separation strategy (See. 2.1 basics of print data separation)
- Print run stability -> is used to establish routines for performing a remedial operation by means of the needed warm up time or the number of sheets that needs to be taken into consideration for profiling
- Coverage of spot colours
- The dependence on environmental factors such as temperature and relative humidity.

For ECG printing processes, also, it is recommended to test the printing-related properties including the influences of the material combinations and control parameters without the influence of colour management. For this purpose, the Fogra 7C test form for industrial common CMYKOGV-like printing processes can be used.

Step 5: Calibration (Adjustments):

Contrary to the "ISO usage", calibration (in the context of the common usage) is the process of adjusting a printing system such that it produces a solid coloration and tone reproduction that are believed to be correct. ISO 13655 defines calibration as a set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards. The different calibration methods used in the field do vary quite a lot among digital printing solutions. For that reason only the analogy with the over- and under-inking to be used in offset printing will be used here. It is valid both for inkjet and electrophotographic printing and indicates which colours might be achievable when more or less ink is deposited to the substrate.

One of the principles upon which PSD is based is that electronic tools exist that allow electronic data to be adjusted such that any digital printing processes, that can achieve a specified outer gamut, can produce the within gamut image colours specified by the appropriate reference characterization data. This allows printing aims to be process independent. If the available settings however do not allow for reaching the intended ink limit, all further steps can be ignored. Once the intended aim values have been achieved and colorimetrically confirmed, it is certainly possible to use the resulting (colour blind) densities to establish a remediation operation. Those process control aims are easy means for the printer to restore the printing condition to its established aim values.

After the solid coloration has been fixed it is time for the linearization. The primary aim of a linearization is to setup the colour output by means of the primary colours in a known and optimal way. The interpretation of "optimal" certainly varies from manufacturer to manufacturer. Hence some calibration routines linearize a printing system with respect to the density or tone values, other prefer the relative lightness CIEL* or equal ΔE-steps going from paper to the solid. The concrete choice of the linearization is of secondary concern since it will be covered and compensated by the following characterization and profiling step. The linearization must not be restricted to four 1-dimensional tone curves (TRC). Furthermore a multi-dimensional colour look-up table (CLUT) can also be used to allow for a known behaviour extending the 4x1D approach.

Hint:
Solid coloration describes the CIELAB values of the primary and secondary colours. Density values are deprecated for this purpose. They might be extremely helpful for a sensitive diagnosing of an underlying process variation

Step 6: Characterization & Profiling:

The aim of characterization and the following profiling is to create a new custom destination profile. Custom Destination Profiles can be created for each machine to fine tune the colour output of your press and improve colour matching between machines. It also improves colour consistency over time.

The procedure starts with the printing of CMYK-based test charts such as ECI 2002 (1485 patches) or IT.8/7-4 (1617 patches). Here the layout of the test cart must be compatible with the instrument in use. RGB-based output devices can be used in the same fashion. However vendor specific test charts need to be used.

Multi-ink printing systems such as HexaChrome which require a non-CMYK or RGB-based separation are currently not covered by the PSD. Multi-ink systems that can be controlled via RGB- or CMYK are considered the "normal" output systems, since the separation of the CMYK or RGB into the available process colours is done in a predefined way.

The test charts will be measurement colorimetrically, mostly with a chart reader or a scanning measurement device. The software program takes the readings and creates a set of measurement (characterization) data. The resulting tristimulus values (and more often the spectral reflection factors) are reported in a way that can be interpreted by the receiving software (e.g. for profiling, analyzing or visualizing).

A number of International Standards used by the graphic technology community require the reporting of measured and/or computed data. Several of these standards, e.g. the ISO 12642 series and ISO 13655, contain suggested formats for the data to be exchanged. These have used the ASCII keyword value pair approach and have been widely used by some industry segments. ISO 28178 is intended to support all existing and future graphic arts standards that require the exchange of measured, computed, or process control data and the associated metadata necessary for its proper interpretation.

It is important to select the measurement condition appropriately, see 2.3.1., in order to assure to match the measurement mode of the reference printing condition to be simulated. Based on the findings of step 4 many prints should be measured, averaged, smoothed and scrutinized with respect to outliers. Here the pertinent drying time needs to be taken into consideration. . Programs that allow for a detailed inspection and optimization of the measurement data should be used, if possible. They do check for redundant patches in order to estimate the within sheet uniformity or lack thereof.

Hint:

It is recommended to use the random layout of the test charts. In addition the patch size should be large enough to allow for a high degree of repeatability. Patch sizes below 6x6 mm should be avoided, unless a scanning technique is used to compensate for this. The rougher the substrate the bigger the patch size and of course the inherent (effective) measurement aperture.

To remember

Average, average and average .....

Profile creation

Based on the established printing condition a colour transformation will be created that either maps from a known source colour space into that actual printing condition or by means of a ICC output profile. The first one is a so called DeviceLink profile that maps from e.g. FOGRA39 or FOGRA51 directly to the actual printing condition. When setting up this transformation two important settings needs to be sorted out namely the gamut mapping and the black separation strategy. More information on this can be found in chapter 2.5.1.

There are template or wizard based profiling systems that incorporate the created destination profile directly into the workflow. In other circumstances the user is required to put the created profile in the right folder including a RIP update. As indicated in Figure 5.1 this profiling step can be iterated. Such a step is usually recommended since it increases the colour accuracy.

Step 7: Validation (with and without colour management):

The following validation or diagnosis steps do help to inspect two different aspects:

¬ The stability of the printing system and the specific printing condition („1:1“)

¬ The interplay of colour transformations and the before mentioned printing stability.

The first represents any kind of changes or drifts from the original settings. The device mode transform (1:1) means that only 1-dimensional transforms are applied also known as channels preservation. Practically you can check this by visually checking "pure" vignettes for potential "contamination".

By using the device mode transformation for checking print related issues and the simulation mode transformation for additional colour transformations a clear problem identification is possible. Once both validation methods are in place, existing software tools for comparing aim and current values can be used for diagnosis. The selection of the aim values surely differs with respect to the used procedure. Also additional warning tolerances (traffic light symbol: green, orange and red) might be used.
The Fogra MediaWedge CMYK V.3 is recommended for both validation methods.
The inspection of the final colour output relies on two things. A stable printing condition that is adequately characterized and a colour management on top that performs high quality colour mappings. It allows to check if the customer expectation has been met. Since the colour characteristics of the reference and actual printing conditions often differ, combining different inks might be necessary. This leads to the "contamination" of "pure" colours or gradients, which can easily be checked by visual inspection.

Hint:

Using the device mode transform (1:1) an erroneous printer (destination) profile won't be found since it won't be used in that "bypass" mode.
However: The usage of composed / process grey patches that are derived from a reference characterization data set such as FOGRA39 is not appropriate, since the actual printing condition might comprise a slightly different grey balance.

Hint:

In step 4 you can find out if channel preservation is possible, at least for the primaries, when comparing the hue angles in the corresponding spider web diagram. DeviceLink profile with "pure primaries" can be used to test the result. See also 2.5.1.

Step 8: Quality Assurance

In the last step the achieved colour accuracy and consistency is to be monitored for a number of machines across different printing sites - over time. For achieving this, a destination profile is tailored not to one specific machine but to a number of printing machines sharing similar printing behaviour. Each of these machines will then be adjusted to meet the average printing condition, where this average "profile" is usually not a maximum gamut one but slightly reduced to allow for better adjustment from the different press behaviours.
The time-based tracking of the press characteristics, both before and after calibration, is a helpful tool for a unified quality management system. More and more programs able to perform such kind of conformance evaluation are web-based systems, which increase accessibility for the print service provider. Here the reporting is not limited to the validation or monitoring results. They can also be used to deduce corrective actions.

Hint:
The following paragraph outlines minimum requirements for the quality report (protocol)

Hint:
PSD-certified companies need to send such a protocol to Fogra on a monthly basis.

Summary:

The described process steps build the foundation for a guide for process control of digital printing upon the following principles:

- To establish actual printing conditions that ought to allow for the maximization of the capabilites of an individual press or printer.
- To determine simple, objective and visually-based means for maintenance such as density values, which allow for a sensitive monitoring and adjustment of the colorimetrically defined printing condition (characterized by the destination profile).
- To provide modular and vendor neutral principles that can be used by manufacturers to structure their content.
- To separate between print-based and colour-management-based errors.
- To periodically track the quality of the print quality (drift analysis).

It is important to note that the term "quality" as it is used within the PSD does not refer to an absolute level of a print image attribute such as stripes (or lack thereof). It is used as the degree of closeness as to which a reference or aim has been met.

Finally the importance of the driving should be highlighted. Whilst some of the process steps are not affected by the chose data path (e.g. over- and under-inking) there are other operations that strongly depend on the chosen driving by means of the individual RIP- and/or Front End settings.

Hint:
When establishing a printing condition the device mode transform should be used for the process steps 1 to 5. The printer profile created in step 6 must be incorporated into the RIP-settings. That is needed since otherwise the additional test charts to be printed won't be affected by the created profile.

5.2 Requirements for the quality report

Checking the stability of a printing system should be done in a regular manner by printing, measuring and evaluation a test chart or control strip compliant to ISO 12647-7. These requirements refer to:

- Solid tones of the chromatic primaries and their secondaries C,M,Y,R,G,B (6 patches);
- Mid- and shadow tones of the chromatic primaries and their secondaries C,M,Y,R,G,B (12 patches);
- A first half-tone step scale composed of the primary colour K only including the solid (e.g. 6 patches);
- A second half-tone scale composed of the primaries C, M, Y such that it roughly replicates the colours of the first scale (bullet c) for an average printing condition ("grey balance") (same number of patches as for bullet c);
- A selection of critical tertiary colours such as flesh tones, brown, aubergine, violet (e.g. 15 patches);
- The simulated print substrate colour of the production printing condition (1 patch).

Hint:
We recommend to use the Fogra MediaWedge CMYK V.3. It is an internationally known and recognized control strip - measurable with almost all programs

The aim or reference values could be twofold. It could be either established reference characterization data sets such as FOGRA39 or FOGRA51. In this case the system is checked both for correct printing and colour management. Aim values could also be individual (material and/or machine specific) values established, representing the internal "house standard".

Category:	Normative: (shall)	Informative (should):
Colour	Substrate (ΔE (Paper))	
	Primaries (max ΔE (CMYK))	Primaries ("vendor/user optimized" -proprietary - score value in %)
		Secondaries ("vendor/user optimized" -proprietary - score value in %)
		Tertiaries ("vendor/user optimized" -proprietary - score value in %)
	Grey balance (max ΔCh (composed grey))	Grey balance ("vendor/user optimized" -proprietary - score value in %)
		Total (total quality score in %)
		Additional information
Resolution:	–	mis-registration ("vendor/user optimized" -proprietary - score value in % or other figures)
		Additional information
Homogeneity (within wedge)	–	Deviation of process colours (within and/or across sheet depending on the position of the wedge) [only if doublet's are present]
		Additional information

Category:	Normative: (shall)	Informative (should):
Meta-Data	Colour difference formulae	Process Control information for error analysis (pip change, paper change, new linearization etc)
	Combination (printer, print mode, print speed, reference printing condition)	Time after printer (wet, dry etc)
	¬ Measuring mode (M0, M1, M2 M3) ¬ Substrate name ¬ Mass per area	Additional information: ¬ Vendor ¬ Thickness/opacity ¬ Gloss ¬ OBA amount (ΔB or $\Delta CIEb^*$) ¬ Operator name ¬ Time&date of last profiling ¬ Time&date of last printer calibration
	Backing (wb, bb or sb) Time and Date of printing	

Tab. 5.1: Overview of the required information for the quality report.

In case there are proprietary, vendor specific evaluations (score values) it is not required to publish the concrete way of calculation. However it is recommended, since otherwise it is not possible to reasonably compare different score indices.

Update

5.3 Process control guidelines

5.3.1 Recommendations for Multicolour printing (ECG)

Multi-primary printing systems, also known as multi-color printing systems, require special test forms for characterization. Fogra PSD covers all processes that extend CMYK with additional inks to increase the achievable colour gamut, hence ECG (Expanded Colour Gamut). The core requirement for the test form is the used tonal grid used, i.e. the tonal value combinations. In that light, a ECG process that adds orange to CMYK (CMYKO) requires slightly different tone value combinations than a ECG process that adds green to CMYK (CMYKG). In those cases, it is advisable to use the test form recommended by the profiler builder application - both with respect to the grid points and the pertinent layout. For the industrial common CMYKOGV process, Fogra has developed a vendorneutral test form that is recommended for characterizing all conventional and digital CMYKOGV processes. Multi-primary printing systems that can be controlled via RGB or CMYK are regarded as „normal" output systems, since the separation of CMYK or RGB colors into the available process inks is done in a predefined manner („black box").

Hint:
Name the additional inks consistently - from the determination of measurement data to profile creation and workflow configuration.

The four paged Fogra test form comprises, as shown in Fig. 5.2:

¬ The four-page characterization test chart with 4884 colour patches
¬ The "process control frame" around the test form on each page as an additional part of the characterization test chart for fast measurement of tone value increase and gray balance
¬ The test elements for analyzing essential process parameters such as moiré and register accuracy
¬ The test elements for checking the normative criteria according to ISO 12647-7/8 such as vignettes smoothness and resolution.

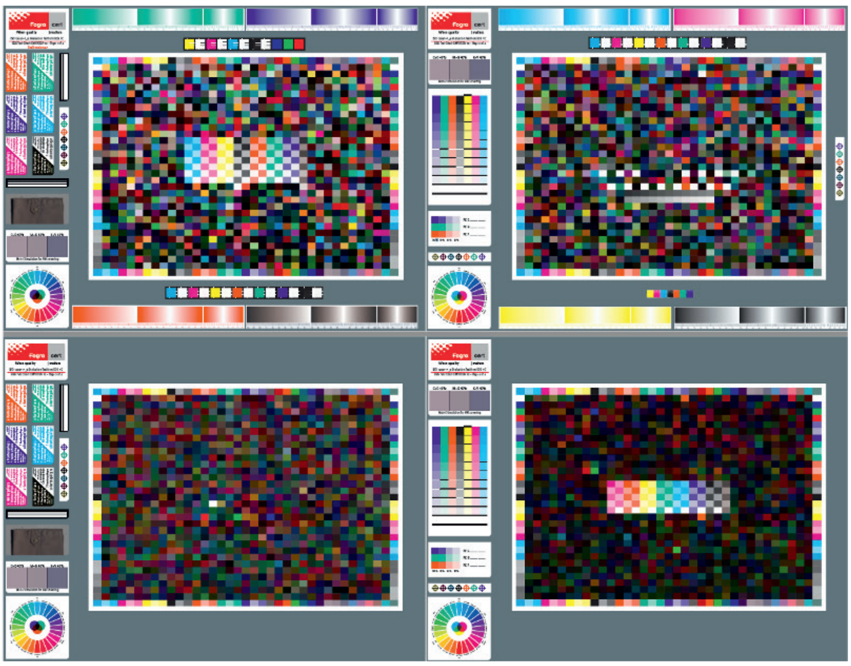


Fig. 5.2: The Fogra ECG-7C test form consists of four pages in DIN A3 format and can also be used individually in sequential form (page 1 or page 1+2 ...).

When using the test form, it is essential to ensure that the colour channels of the additional channels OGV in the test form are correctly assigned with the actual inks used,
e.g. Orange should be mapped to the colour that lies between yellow and magenta in the colour space, as stipulated in Tab. 5.2:

Additional channels in the test form	**Suitability for chromatic neighbouring colour between**	**Example**
Orange	Yellow and magenta	Orange, red
Green	Cyan and yellow	Green
Violet	Magenta and cyan	Violet, blue

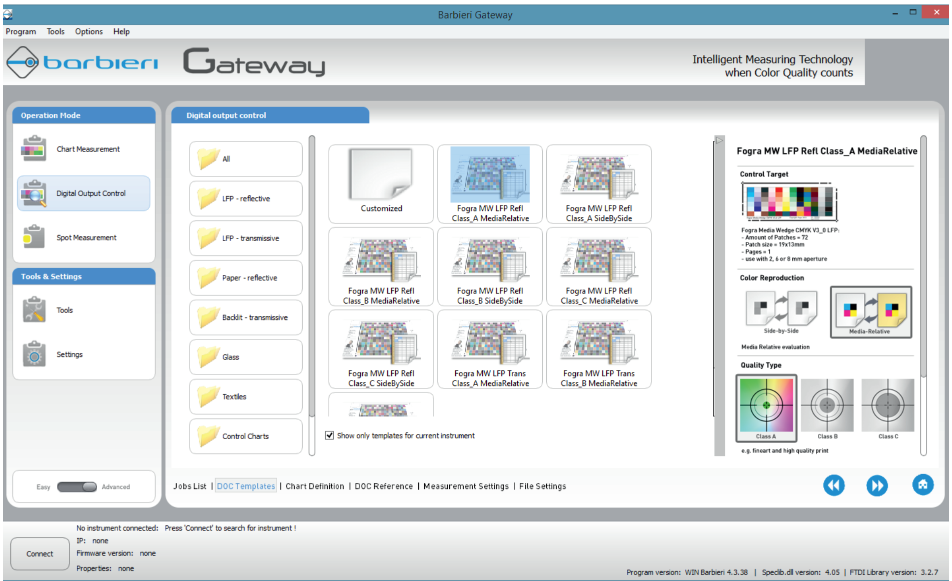
Tab. 5.2: Assignment of the additional colour channels of the Fogra ECG-7C test form

5.3.2 Process Control Solutions provided by: Barbieri

Barbieri spectrophotometer with enabled DOC „Digital Output Control" mode can be used to measure and evaluate the Fogra MediaWedge.
Please note: Because of the measurement aperture, some measurement instruments support only the evaluation of the "Fogra MediaWedge V3.0 LFP".

Creating a new job in the Barbieri Gateway Software

Please select the operation mode "Digital Output Control" in your Barbieri Gateway measuring software and create a new job for your selected printer – media combination. In the course of creating a MediaWedge V3.0 LFP job, you can find different presets (templates) in the "Fogra PSD" folder. These templates were created for different fields of application and vary in their settings like media relative, Side-by-Side and the different Fogra quality levels. The reference used to compare with the measurement can be a prior measurement or a characterization data set like FOGRA39.



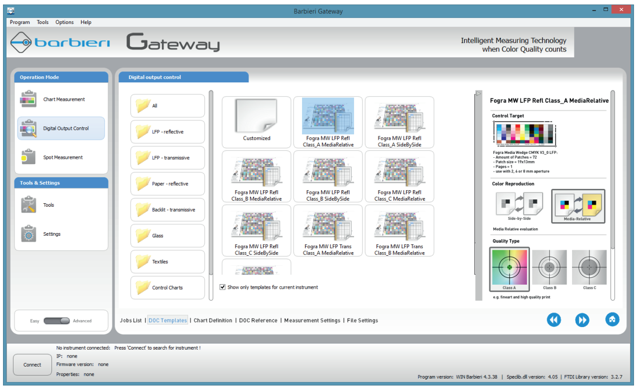
DOC (Digital Output Control)

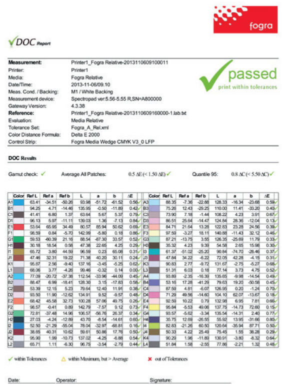
Barbieri DOC deals with process control in the sector of large format printing and makes it possible to compare colour values of an actual measurement to prior defined reference values. In this way, colour differences can be detected immediately, a loss of production can be reduced and a maximum of quality can be achieved and documented.
Next to perform process control directly on the printer using the innovative SpectroPad and its special build-in DOC software, DOC is also available for Spectro LFP and Spectro Swing in combination with the Barbieri Gateway measurement software.

Measuring Fogra MediaWedge using the SpectroPad

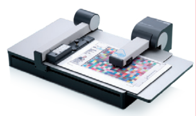
To measure your prior in Gateway created job wireless with the SpectroPad please transfer your job file to the measurement device. Measuring in wireless mode has the advantage to work directly on your printer and to see your DOC results immediately after the measurement on the touch display of the SpectroPad.

All measurements and reports can be synchronized with your Computer by Wi-Fi or USB and you have the possibility to review them anytime in your Barbieri Gateway Software.



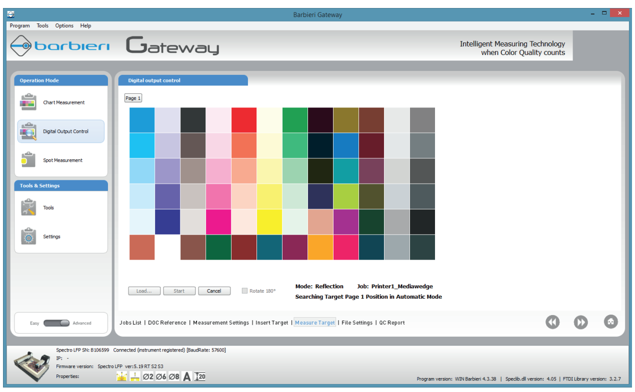


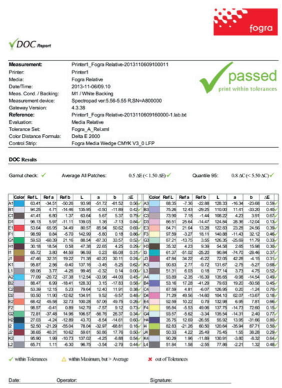
Measuring Fogra MediaWedge using Spectro LFP or Spectro Swing



The measurement of DOC jobs is performed directly in your Barbieri Gateway Software. Please select your prior created job and double-check the job settings. The job is been measured automatically afterwards and a DOC Report will be created. These reports are saved in your Barbieri Gateway Software as PDF files and can be reviewed anytime.

All measurements and reports can be synchronized with your Computer by Wi-Fi or USB and you have the possibility to review them anytime in your Barbieri Gateway Software.





5.3.3 Process Control Solutions provided by: Caldera

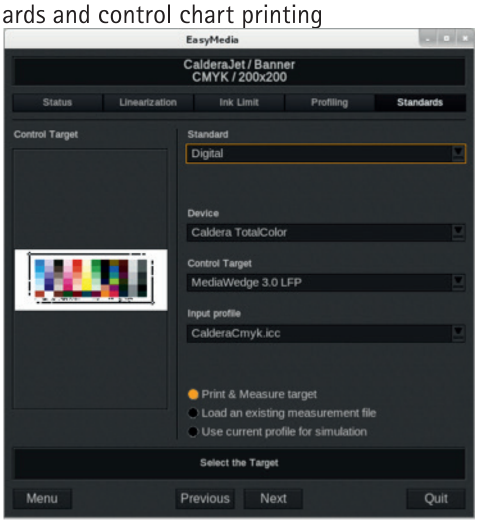
Print Standard Verifier

Caldera's Process Standard Verifier is a tool used to punctually check if the printing process conforms to specific industry standards like Fogra PSD Absolute and Media Relative.
It provides an answer to the ever rising requests for certifications from the digital printing business.

Print Standard Verifier process in three steps

The process, made easier by EasyMedia's wizard, is done in only 3 steps as long as calibration and profiling has already been completed:

¬ Choice of the standards and control chart printing



¬ Target measurement in EasyMedia using a correctly calibrated spectrophotometer.

¬ Then the results are clearly displayed. They are easily recognizable using the following color codes:

Green logo = the printed area is conform and the printing process can most likely pass a certification. Print Standard Verifier also gives you the level achieved by your printing process: A, B or C depending on the quality reached.

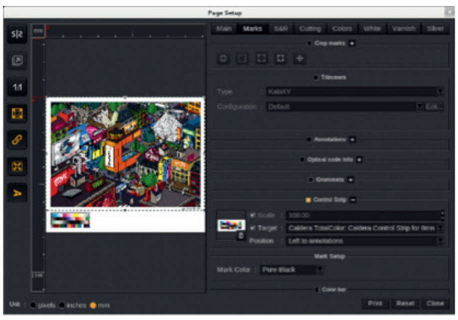
Orange logo = some of the conditions are fulfilled while others are not too far off. However it is not good enough to successfully pass the certification. Some parameters can most likely be changed in EasyMedia to improve the results.

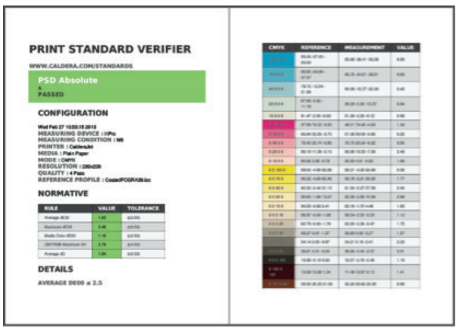
Red logo = the certification will never be a success. Results are too far off from the requirements.

The results are displayed swatch by swatch so the user knows on which points of the standard the process failed and can try to correct them.
For further information about the supported standards and complete results information, please visit our dedicated webpage: https://www.caldera.com.

Checking the print configuration at any time

In order to help you perform day to day print configuration checks, Caldera allows you to add the Fogra MediaWedge at the end of your jobs. The target is then printed at the end of the job and can directly be measured and interpreted in the Print Standard Verifier tool to let you know if your process is still conform or not.
Performing regular checks of the printing process is necessary to monitor it and ensure that it still follows the standards requirements over longer periods of time.





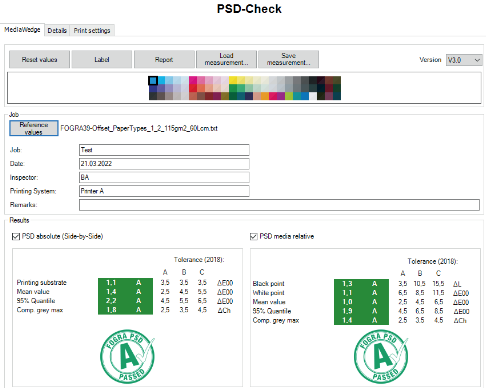
Hint:
Be careful, the standards control option is not a certification. The printing process can only be certified by an accredited technician from the Fogra organization.

Hint:
To help monitoring of the printing process, results can be downloaded in XML, PDF (complete and light) and HTML.

5.3.4 Process Control Solutions provided by: Techkon

SpectroConnect PSD-Check

With PSD-Check, users can check if the printing process conforms to Fogra PSD-2022 within a few seconds. All layouts of the Fogra MediaWedge Version 3.0 are supported and both evaluation methods, Absolute (Side-by-Side) and Media Relative are available. Any characterization set (Fogra standard) can be selected as target.

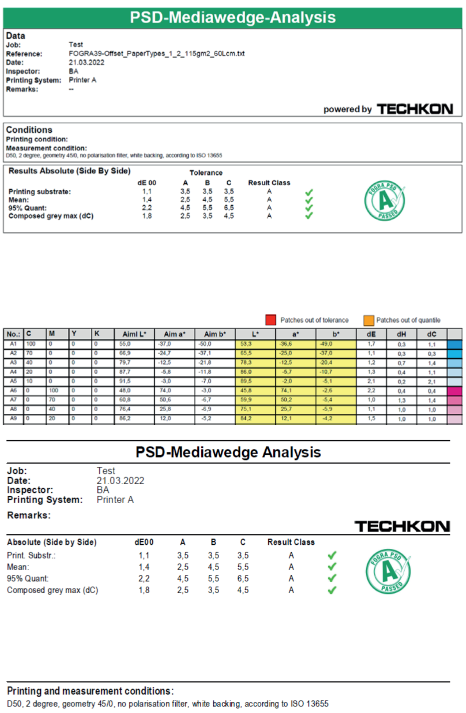


Process Control Procedure

Select Fogra Mediawege layout, choose desired characterization set (refrence printing condition), enter additional job information, check evaluation method PSD Absolute (side-by-side) or PSD Media relative. Measure the patches of the Fogra Mediawedge, preferably with the integrated scan function of the Spectrophotometer SpectroDens via USB cable or via WLAN. Save the values to review them at any time.

Analysis and Reporting

The results and classification of the quality level are indicated immediately after measuring the colour patches. The details can be viewed in a list showing patches out of tolerance and out of quantile. The results can be reported with a label and a full report print out with customized logo.



No.:	C	M	Y	K	Aiml L*	Aim a*	Aim b*	L*	a*	b*	dE	dH	dC
A1	100	0	0	0	55,0	-37,0	-50,0	53,3	-36,6	-49,0	1,7	0,3	1,1
A2	70	0	0	0	66,9	-24,7	-37,1	65,5	-25,0	-37,0	1,1	0,3	0,3
A3	40	0	0	0	79,7	-12,5	-21,8	78,3	-12,5	-20,4	1,2	0,7	1,4
A4	20	0	0	0	87,7	-5,8	-11,8	86,0	-5,7	-10,7	1,3	0,4	1,1
A5	10	0	0	0	91,5	-3,0	-7,0	89,5	-2,0	-5,1	2,1	0,2	2,1
A6	0	100	0	0	48,0	74,0	-3,0	45,8	74,1	-2,6	2,2	0,4	0,4
A7	0	70	0	0	60,8	50,6	-6,7	59,9	50,2	-5,4	1,0	1,3	1,4
A8	0	40	0	0	76,4	25,8	-6,9	75,1	25,7	-5,9	1,1	1,0	1,0
A9	0	20	0	0	86,2	12,0	-5,2	84,2	12,1	-4,2	1,5	1,0	1,0

6 Evaluation of print products

6.1 Introduction

Reproducing images and documents normally aims for a pleasing reproduction against a virtual reference (or whatever the print buyer has in her/his mind). This involves a creative process that needs to be done before process control and quality assurance of print related workflows start. When preparing data for a given printing condition, defined by a reference characterization data set, the pros and cons of that printing condition need to be taken into consideration together with the customer expectations and preferences. After the data is defined by means of an output referred (print related) colour space (and an appropriate reference such as a softproof, a contract proof or a validation print) it is up to the print service provider to print the expected. The evaluation of print conformance as defined in the PSD always applies a full reference schema, i.e. it will be measured how close a given reference has been met.

In case that a print service provider has to process data which is not prepared for a printing condition, such as RGB image content, they are urged to take the responsibility to perform this ambiguous step. In that case the print service provider should inform the print buyer about that process, since it might involve a significant image difference. It is recommended to use modern ways of visualization for that purpose, such as softproofs within the webshop or a URL to a lowres version of the ripped data. This might also help to raise customer satisfaction. Meeting the requirements of "pretty reproductions" can therefore only be accomplished when the print buyer has a chance to inspect the final print product. In cases where this way of approval, from a visual representation of the ripped data all the way to a contract proof, was not chosen, it is an indication that quality is not of primary concern. Here the service provider might consult the provisions outlined for the conversion of Office PDF documents in chapter 3. The described schema is illustrated in Figure 6.1.

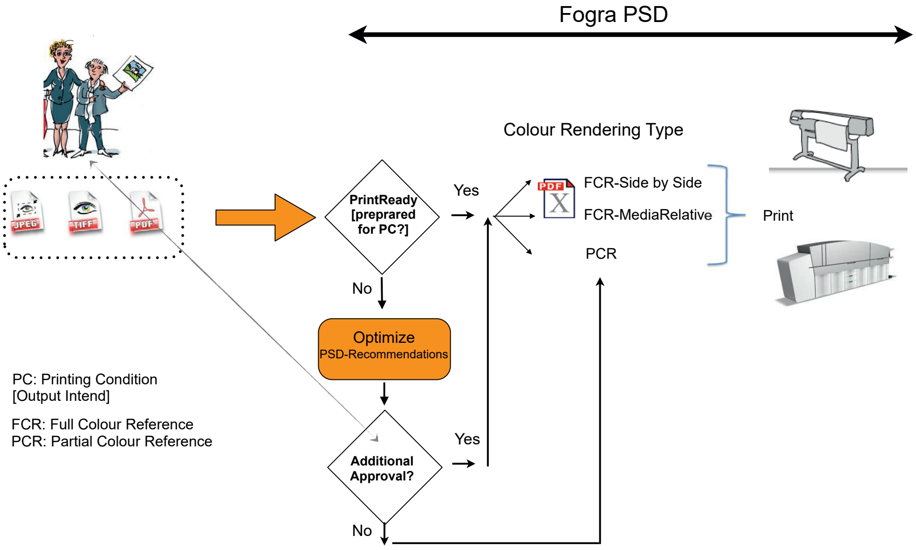


Fig. 6.1: Schematic workflow of the colour reference to be choosen according to PSD. Incoming data will be checked whether it is print-ready or not. After an optimization according to chapter 3 and an optional but recommended approval the reference printing condition (e.g. FOGRA51) can be matched either media relatively or absolutely (Side-by-Side).

In brief

Two printing gamuts are similar when you talk about colour differences instead of different colours.

Hint:

What is well defined image content?
Image data that is output referred is well defined since it defines colour by means of an print related output. In other words most of the RGB-based image data is picture or scene referred and therefore not well defined.

6.2 From colour to the printed image

Conformity of print products is most restricted toward the accuracy to which the colours have been reproduced. Prior definition of expected image and product quality can be based on specific print image quality criteria. These criteria address colour rendition, homogeneity (uniformity), resolution, and artefacts, in addition to permanence aspects such as light fastness or rub resistance. These four (five) categories are the pillars of the process independent evaluation of printed matter.

Certainly, colour accuracy plays a dominant role. In chapter 2.6 it was shown that the established way of colour reproduction and viewing does not reflect typical uses cases well. Hence the colour reproduction according to PSD will be extended by taking the following aspects, which are also part of ISO 15311, into consideration:

¬ Evaluation of print image quality based on process independent image quality attributes. Print quality attributes are categorized into colour and surface finish, homogeneity, resolution and artefacts, plus permanence requirements.

¬ Consideration of different colour reproduction/viewing types, namely: Side-by-Side and media relative.

¬ Facing the different needs of different market sectors by providing alternative tolerance bands termed A, B and C.

This additional information requires prior agreement and negotiation between the print buyer and the service provider. Therefore an exemplary job sheet is provided in section 1.3.

6.3 Image Appraisal: Side-by-Side and media relative

Concrete methods for evaluating colour rendering between an original and a reproduction are known since the publication of the 1931 CIE standard observer - hence for more than 80 years. They are referring to an image appraisal that assumes a simultaneous viewing of both the original and the reproduction - positioned juxtaposed. This way of appraisal is called "Side-by-Side". The plethora of devices and substrates in digital printing and the corresponding variety of use cases challenge this concept of colour reproduction/viewing. The most prominent nature of the absolute reproduction is the paper simulation, which is needed to compensate for the different paper shades. Such a paper simulation, however, is often not needed for many use cases or applications. Just the contrary, often print products with a paper simulation are refused by the print buyer. That is the case since the print product won't be seen directly next to the original in a "Side-by-Side" fashion. Hence print service providers are faced or demanded to switch off the paper simulation. The established "PSO-like" evaluation would most likely result in non conformance due to the colour difference in the paper colour.

For this reason, an old-fashion method, e.g. known from densitometry, will be used, which normalizes or adapts for the paper colour. This approach is simplified by considering colours relatively to white. Allowance is made for the fact that observers tend to perceive not in isolation but with reference to a framework provided by the environment. Such a framework is often the (unprinted) substrate. The media relative approach is intended for those applications where the final print product is subject for individual viewing or observation. It assumes that the observer fully adapts to the individual substrate, which is practically the case for most non-colour media. While keeping a certain level of predictability this media relative reproduction (and evaluation) is not applicable without limits. For instance it makes no sense to render from FOGRA51 ("premium coated offset") to IFRA26 ("newspaper printing"). For that reason there are detailed requirements for the source and destination gamut to make sure that both gamuts are similar in size and shape.

Hint:

While the quality of the established reproduction method (side-by-side) results from the simultaneous comparison of two adjacent prints under norm light, the media relative approach is conducted as follows:

- Test person sees reference (proof, softproof or Validation Print)
- Test person takes a break while the reference is removed.
- Test person sees the reproduction (by itself) and compares the quality with their memory.

In case image content needs to be reproduced on a gamut that is substantially smaller than the reference, large colour differences can be expected. These depend on the used gamut mapping algorithm and the actual gamut differences. If gamut mapping algorithms originating from different vendors are used, the reproduction might show significant differences. That is practically termed "not consistent".

This fact calls for another approach which allows for consistent rendering across different gamuts. Such an approach is termed "common appearance" and still an active field of research. It is planned to incorporate such an approach as soon as there is enough substantiation for a practical, vendor neutral implementation.

6.4 Colour accuracy for production printing

The following tolerances are part of the PSD PrintCheck. It is necessary that the Fogra MediaWedge V3 is present. In cases where imposition does not allow for a control wedge, a dedicated testform (e.g. the Fogra Image Quality testform or the process control test form including customer specific images and control elements) should be printed prior and after the print run, undergoing the same data transformation as the pertinent image data.

Spot colours:

Spot colours typically occur in three different ways. The most prominent way is the usage of a solid, e.g. 100% Fogra-Red. The second occurrence is the usage as tint values, e.g. 50% Fogra-Red. The most complex way is the usage of spot colours that overprint with other process or spot colours (e.g.: 30% Fogra-Red on top of 80% „Warm Grey" and 25% Cyan).

ProcessStandard Digital (PSD) currently only covers the first occurrence, namely the usage of spot colours as solids. It is important for the colour communication to agree on the reference to be used. It is recommended to use either a physical sample or the colour definition as part of a PDF/X file (colorants dictionary entry).

Here it is not of primary concern if the spot colour is reproduced by means of a separate colorant or by overprinting of the process colours. However, for process control reasons it plays a vital role due to screening effects and risk of higher variation within the print run.

Accuracy of evaluation

When evaluating prints it is important to take the correct rounding into consideration. The basic rule is that the measurements shall be rounded to the precision of the given tolerance. Two examples are given in the following tables:

Rounding	Value ΔE^*_{ab}	Tolerance: $\Delta E^*_{ab} \leq 3$ – Result
Not rounded – **wrong**	3.451	Wrongly rounded, outside tolerance
Rounded to two decimals – **wrong**	3.45	Wrongly rounded, outside tolerance
Rounded to one decimals – **wrong**	3.5	Wrongly rounded, outside tolerance
Rounded to zero decimals (integer) – **right**	3	Rounded correctly, compliant (within tolerances)

Tab. 6.1: Example for how to round measurements. Since the tolerance is an integer the rounding shall be done with zero decimals.

Rounding	Value ΔE^*_{ab}	Tolerance: $\Delta E^*_{ab} \leq 3.0$ – Result
Not rounded – **wrong**	3.451	Wrongly rounded, outside tolerance
Rounded to two decimals – **wrong**	3.45	Wrongly rounded, outside tolerance
Rounded to one decimals – **right**	3.5	Rounded correctly, outside tolerance
Rounded to zero decimals (integer) – **wrong**	3	Wrongly rounded, but erroneously within tolerances

Tab. 6.2: Example for how to round the measurements in order to assess conformity. The measurement value must be rounded to one decimal (as defined by the tolerance). In this case there is no compliance.

Hint:
It is recommended to use both visual images and test elements for the test form prepared in CMYK. The Fogra testform can be used to get some ideas.

Hint:
Simulating spot colours with process colours often requires the usage of tints instead of solids. Depending on the used screening this might result in unwanted uniformity problems. In addition the interplay of 2 or more colorants is prone to higher variations than using only one ink.

Hint:
Although the required Fogra MediaWedge CMYK V3 has no redundant patches, an arithmetic average of the CIELAB values shall be conducted before the evaluation. This could be the case when mutliple wedges are on one print..

6.4.1 OK-Sheet: Side-by-Side Evaluation

The deviation tolerances are derived from comparing the OK-print with the corresponding values of the reference printing condition. It could be thought of as the ability of a printing system to be successfully calibrated as demonstrated by the colour difference between the "first" sheet (OK-sheet) and the reference characterization data set. Table 6.3 lists the tolerances for the three tolerance bands A, B and C for the practical evaluation (print check). The PSD Print Check colour accuracy evaluation is limited to the Fogra MediaWedge V3.0. An extended scrutiny, e.g. based on large test charts, is subject for the system check.

Patch in digital printing form	Quality Type C	Quality Type B	Quality Type A
Substrate	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 3.5$
All patches	Average $\Delta E_{00} < 5.5$ 95% Quantile $\Delta E_{00} < 6.5$	Average $\Delta E_{00} < 4.5$ 95% Quantile $\Delta E_{00} < 5.5$	Average $\Delta E_{00} < 2.5$ 95% Quantile $\Delta E_{00} < 4.5$
Grey Balance patches*	Maximum $\Delta C_h \leq 4.5$	Maximum $\Delta C_h \leq 3.5$	Maximum $\Delta C_h \leq 2.5$
*ΔC_h is explained in chapter 2.3.			

Tab. 6.3: Deviation tolerances for Side-by-Side reproductions.

The reproduction of spot colours shall meet the requirements stipulated in Table 6.4.

	Quality Type C	Quality Type B	Quality Type A
Maximum colour difference	$\Delta E_{00} < 5.5$	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 2.5$

Tab. 6.4: CIEDE2000 tolerances for spot colours.

It is recommended to check the spot colours coverage of the typical production printing combinations in order to identify and use a combination that allows for an appropriate spot colour match.
Note: Spot colours are typically distinguished between "process ink emulation" and "real spot colours" using an additional ink. The latter one often results in a more uniform reproduction since there are no screening effects. Spot colours not within the gamut of the chosen printing combination are handled the same way as CMYK content which lies out of gamut. The benefit of using "real spot colours" will automatically become obvious when saturated spot colours ought to be reproduced to a high degree, i.e. comprising a small colour difference.

6.4.2 OK-Sheet: Media Relative Evaluation

The control strip shall be the Fogra MediaWedge CMYK V3. The media-relative evaluation is only applicable for actual printing gamuts similar in size and shape to the gamut of the reference printing condition, see Table 6.5. In order to evaluate the gamut difference the following 10 patches need to be measured for both the reference and the actual printing condition:

- Process colour black for the reference (Ref_K100) and actual (Act_K100),
- Composed Grey for the reference (Ref_CMY100) and actual (Act_CMY100) and
- Overprints of the chromatic process colours for the reference (Ref_CK100, Ref_MK100, Ref_YK100) and actual (Act_CK100, Act_MK100, Act_YK100).

Hint:
Use the free Excel spread-sheet: https://fogra.org/en/downloads/work-tools/processstandard-digital-psd

Based on the minimum CIEL* lightness values for the reference (Ref_Min_CIEL_Dark) and the actual printing condition (Act_Min_CIEL_Dark) it will be checked if the shadow parts are comparable. In order to compare the highlight areas, the ΔE_{00} total colour difference of the measurements of the substrate patch of the reference (Ref_paper) and the actual printing condition (Act_paper) will be computed.

	Black point difference	White Point difference
Tolerance Quality A	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 6.5	ΔE_{00} (Ref_paper, Act_paper) < 6.5
Tolerance Quality B	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 10.5	ΔE_{00} (Ref_paper, Act_paper) < 8.5
Tolerance Quality C	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 15.5	ΔE_{00} (Ref_paper, Act_paper) < 11.5

Tab. 6.5: CIELAB tolerances for gamut differences to check if media-relative is applicable. The colour differences for the white colour are very similar when using ΔE^*_{ab} or CIEDE2000. The CIEDE2000 tolerances shall take precedence. CIELAB 1976 colour differences are given in brackets.

Hint:

New tolerances!

The specified tolerances shall be communicated as "PSD 2022".

Only if the criteria of Table 6.5 have been met, the media relative evaluation shall be conducted. For the PSD print check evaluation, the 72 patches of the Fogra MediaWedge V3.0 shall be used. The colour differences shall agree with Table 6.6.

Hint:

Media relative CIELAB-colour values can be detected easily when the paper has a CIELAB value of 100,0,0.

Patches in digital printing form	Quality Type C	Quality Type B	Quality Type A
All Patches	Average ΔE_{00} < 6.5 95% Quantile ΔE^*_{00}<8.5	Average ΔE_{00} < 4.5 95% Quantile ΔE^*_{00}<6.5	Average ΔE_{00} < 2.5 95% Quantile ΔE^*_{00}<4.5
Grey Balance patches	Maximum $\Delta C_h \leq 4.5$	Maximum $\Delta C_h \leq 3.5$	Maximum $\Delta C_h \leq 2.5$
*ΔC_h is explained in chapter 2.3.			

Tab. 6.6: Deviation tolerances for media-relative reproductions.

There is no media-relative evaluation for the reproduction of spot colours.

6.4.3 Stability within the run (production variation)

Contrary to deviation tolerances which define the difference between an OK-sheet and tabulated data, the variation tolerances refer to the differences within one print run. In ISO 12647-2 and hence PSO the variation tolerances are evaluated by taking the OK-sheet (or set-up sheet) as the reference. Print buyers look for consistent colour printed in different locations and at different times. The best way to achieve within-run colour consistency is to use the average value of the print run, and not the OK sheet, as the reference. The tolerances are depicted in Table 6.7.

In addition the variation tolerance, i.e. the ability of a printing system to maintain consistency between the same colour patches printed in the same locations on the sheet over the press run, is assessed by checking that at least 70% of the randomly picked sheets are in conformance to the deviation tolerances. In order to evaluate a print run at least 20 samples must be randomly selected. The following patches needs to be taken into consideration.

¬ Primary and secondary colours („CMYKRGB“)
¬ Midtones (40% to 50 %) of primary colours („50 % CMYK“)

	Quality Type C	**Quality Type B**	**Quality Type A**
CMYKRGB, 50 % CMYK	Maximum (95 % quantile ΔE_{00}) < 5.5	Maximum (95 % quantile ΔE_{00}) < 3.5	Maximum (95 % quantile ΔE_{00}) < 1.5

Tab. 6.7: CIEDE2000 tolerances of primary and secondary colour solids and primary colour mid-tones – between any print sample and the average of the 20 samples.

The "PSD PrintCheck Digital" is also available as a separate Fogra certification. Please consult the webpage for more information.

6.5 Colour accuracy for large format signagne printing

The colour accuracy requirements are currently identical to those defined for production printing.
The only difference is the imposition and the print-run evaluation. Here each print is considered as an OK-sheet.
The "PSD PrintCheck LFP" is also available as a separate Fogra certification. Please consult the webpage for more information.

Update

6.6 PSD related certifications

Evaluating print products quickly results in the finding that it is impossible to address different use cases with only one set of requirements. In light of different market needs three categories can be identified. They reflect typical expectations of manufacturer (1), print service provider (2) and end customers (3).

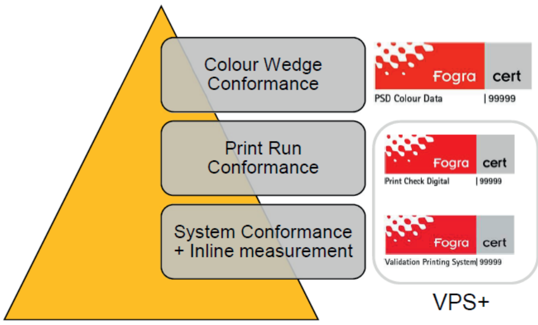


Fig. 6.2: Visualization of the three typical customer segments and the corresponding Fogra certification. The implied hierarchy allows for getting a high level of quality by testing only a subset of quality metrics. For instance, a user with a VPS certified press only needs to check the colour accuracy.

1. Manufacturer: They are often interested to rigorously check if an entire printing system, comprising of representative machine and material parameters, meets the expected criteria for the pertinent application or use case. Originally, the so-called System Check, part of ISO/TS 15311-2, was designed to meet that expectation. For many reasons the System Check was not successful to serve that needs. Based on the well-established Validation Printing System certification, that focuses on the print image quality for a design proof as defined in ISO 12647-8, the additional PSD-PrintCheck certification served as the perfect tool to meet the manufactures expectation. The bundle of both certifications is termed "VPS+".

2. Print Service provider: Print houses are typically interested to show the quality of their qualities. That refers on the one hand to a service provider with a high level of colour communication proficiency and on the other hand to proof if a specific combination meets the defined requirements for a typical industrial print job. For the first use case the PSD certification is the right answer. It addresses the entire company by checking and testing the required capabilities with respect to personal skills, software and hardware. The latter print run conformance is checked by the PSD PrintCheck certification.

3. End users: The print buyer is mostly interested that a given print product complies with the industrial typical tolerances. That refers to a print made for a particular printing condition when tested in the field using only a control wedge. That needs are addressed by the PSD Colour Data certification.

Fig. 6.3: All organisational and technical details for all PSD related certifcations can be found on the Fogra webpage: https://fogra.org/en/certification/digital-printing

Update

6.7 Barcode evaluation

Almost all products of modern life carry coded information. Manufacturer data, product identifications, prices, article numbers and much more are translated into machine-readable 1D symbols (bar codes) and 2D symbols (matrix codes).
Over the years, the relevant printing technologies have been adapted to the specific requirements in terms of data preparation and process control and can be described as technically mature. The situation is different in the high-speed inkjet sector, which is becoming increasingly important in the relevant market segments such as packaging and label printing. The high degree of uncertainty with regards to the readability of barcodes and matrix codes on print products manufactured using inkjet printing causes problems for print service providers.
The poor readability of bar codes is, of course, not an intrinsic characteristic of inkjet printing as such, but rather the result of the combination of substrates and high printing speeds that have to be used from an economic point of view. The quality requirements of the highest levels A and B (see Table X) are needed today in high-speed processes, e.g. in parcel distribution systems. Customer requirements vary depending on the application. In applications that are to be classified as slow due to the use of a hand scanner, overall grades C or D are often sufficient. POS applications with very high demands on reading efficiency require at least grade B.

ANSI- Class	Total Grade	Meaning
A	3,5 - 4,0	Very good
B	2,5 - 3,49	Good
C	1,5 - 2,49	Satisfactory
D	0,5 - 1,49	Sufficient
F	below 0,5	Failed

Tab. 6.8: Comparison of the historical but often still used letter classification with the numerical values according to ISO/IEC 154156 (1D codes) and ISO ISO/IEC 15415 (2 D codes).

Fogra Barcode Test Suite

The Fogra Barcode Test Suite allows both, a visual- and a metrological evaluation of barcodes with a barcode verifier device to gather important information about all relevant parameters. This enables print service providers to find out the optimized parameters for their press. The test form was created as part of the Fogra research project Fogra No. 11.004. All assumptions and results presented here are based on findings of this report.

Layout & structure

The „Barcode Test Suite" is a letter sized (DINA4) page with variations of 1D codes (barcodes) and 2D codes (matrix codes). The test page is bordered with a bar arrangement („decorative bar") as well as continuous CMYK stripes. These are used for visual evaluation. The information field in the lower left area lists all essential technical information. The test elements are arranged in four large blocks „A" (horizontal 1D codes), „B" (vertical 1D codes), „C" (2D codes in positive) and D" (2D codes with variable module width). The bar codes are implemented as EAN8 codes and the 2D codes as DataMatrix codes.

Update

For 1D codes, color and bar width reduction were identified as the primary parameters. For the 2D codes, polarity (inverted color) and the smallest module size, i.e. the question of possible scaling were indentifed in addtion to the paramters for 1D codes. With the aim of achieving the greatest possible variation in these parameters, the test form was constructed as shown in Fig. 6.4.

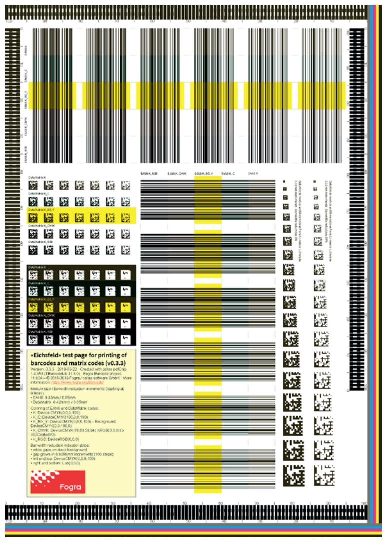


Fig. 6.4: Fogra Barcode test form

Hint:

If you do not have the option to use a barcode verifier, device we recommend a BWR of 30% for 1D codes and 12% for 2D codes as a starting point.

Evaluation of the testform:

Visual:

The aim of the visual evaluation is to identify relevant information for finding barcode specific problems and optimizing the output for a specified printing condition. The printing condition includes all steps of the data preparation (RIP) and the the used material combination. Before starting the evaluation, it is therefore advisable to document all settings in the RIP, as all evaluations refer to this specific combination.

Basic Instructions:

- Print at least 5 copies of the barcode testform
- Read the printing instructions on Fogra website (link at the end of this chapter)
- No tools needed for basic evaluation

The visual evaluation should start with checking for apparent printing errors using the CMYK strips going across the sheet. On the one hand, they make it easier to detect major printing errors such as clogged nozzles, and on the other hand, they can be used to detect a drop in density (so-called inkjet smile) in or across the print direction. To do this, take another copy and hold it in different positions next to the first copy. In direct comparison, the eye quickly recognizes the more less identical deviations. An exact evaluation of image quality is may be carried out with the Fogra Image Quality Testform available from our website.

The color coding can be evaluated with the EAN8 codes of block A, which are arranged one below the other. First of all, it is usually possible to see, even without magnification, whether the first barcode („A1", „EAN K") is printed "pure" with 100% K or not. This information is very relevant, since a the use of K-only is industry standard and higly recommend for good readability. Non pure recreations of this elements might be caused by wrong colour management. Check your RIP settings if Block A is not not printed in CMYK (0/0/0/100). One of the findings of the Fogra Barcode research project was that in most cases, respiration worsens the readability of the barcode. To find out to which extend an active reseparation or any other colormanagment applied improves or worsens the readability of barcodes, an evaluation with the implementation of the other color codes is informative for the visual

analysis at this point. From a practical point of view, it is a good test for the implementation of the intended data preparation. Often, there is ink saving in the Digital FrontEnd (DFE), which was not recognized before in the separation analysis.
The alignment of the print head is another property that can be found out using the test-form. This is done by looking closely at the edge straightness and edge smoothness of the first codes in block A and B. These two quality parameters are often much better with HSI printing parallel to the printhead („garden fence") than printing offset by 90° („ladder"). This is only needed if the orientation is not noted when printing, or not obvious for various reasons. Because the 1D codes are arranged directly below each other without any space in between, any problems in the image register can be seen directly. This is illustrated in Fig. 6.5. It shows the comparison of a barcode printed in deep black, i.e. K+C, in horizontal (left) and vertical alignment (right), which shows clear problems with the image register.

Fig. 6.5: Barcode 100&K + C in horizontal (left) and vertical alignment (right)

Measurement – based evaluation

Fogra offers a spreadsheet called „Barcode Property Finder" for the evaluation with a verifier device. You will find the link at the bottom of this page. For this evaluation a barcode verifer device is needed. It should be ensured that the newest software version is used, so that the device also measures according to actual standards. Also important is proper setup during measurement. This includes both the number of measurements according to the standard (10 measurements for 1D) and the correct measuring backing, Fogra recommend the use of black backing. For an smooth, easy and understandable evaluation, a 4-part video tutorial was created which you can find on the official Fogra Youtube channel.

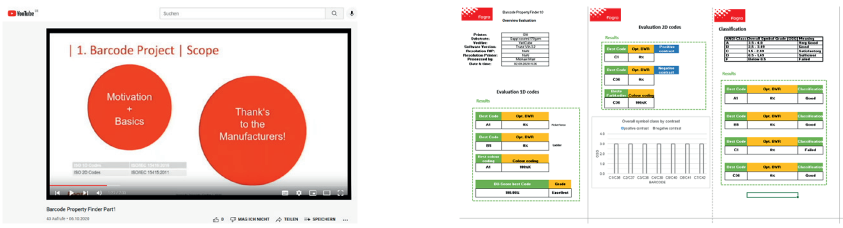


Fig. 6.6: Screenshot of the video tutorial and Barcode Property Finder.

The barcode property finder spreadsheet, the video tutorial and many more can be found under the link below or simply scan the QR code:

https://fogra.org/en/research/digital-printing/barcode-11004

6.8 Permanence and Durability

The definition of permanence requirements strongly depends on the individual use case, to be defined in further parts of ISO 15311. It is not practical to name the magnitude of available standards and procedures for physical properties, permanence behaviour and the effect of environmental factors on printing materials. Therefore the relevant requirements shall be defined by mutual agreement between the print buyer and the service provider.
Most permanence standards and practices are defined by ISO/TC 42/WG 5 "Physical properties and image permanence of photographic materials". Here especially the standards provided by TG 2 (Storage & Physical properties) and TG 3 (Colour, Prints) are of importance. Important standards are ISO/CD 18938 which stipulates light stability, ISO/FDIS 18931 which defines humidity resistance or ISO 18936 and ISO 18924 which specify thermal sta

7 Practical Guidelines & User Tips

This chapter providers practical information for typical applications. These information are mostly taken from the LFP Designer Guide from Color Alliance, hence the applications are currently focussed on large format use cases. It is intended to extend this chapter with additional applications during the course of time. Anyone is invited to share and discuss information for both existing applications and new ones.
The different applications are structured in a way to answer typical questions such as:

¬ What is the appropriate printing system?
¬ What are the relevant permanence and durability properties?
¬ What aspects of date preparation, process control and quality assurance needs to taken into consideration?

It should be noted that the permanence and durability recommendations are not associated with a concrete measurement method. First there are many proprietary solutions used for the pertinent purposed. Second there are different national requirements, so what is required in one country must not necessarily be required in another. The reader is advised to consult the list of measurement methods outline in chapter 6.7.

7.1 Rollup | Banner Display

Fig. 7.1: Typical RollUp banners.

The advantage of this quick and easy to set up display is its good portability. With most roll displays, the base is also used to protect the rolled-up banner. The optimum print media for this application are durable, scratch-resistant, easy to roll and not too thick. It can be made of film or a textile.

If the display is to be used in front of a light or window, attention must be paid to the opacity of the material. The block-out symbol identifies media which are 100% opaque.

In order for the graphic to be able to cope with frequent rolling and unrolling, the print should be protected using lamination (cold or hot). This is particularly important when printing with water-based inks to increase smear resistance. A laminate also offers good UV protection, i.e. the inks will not fade.

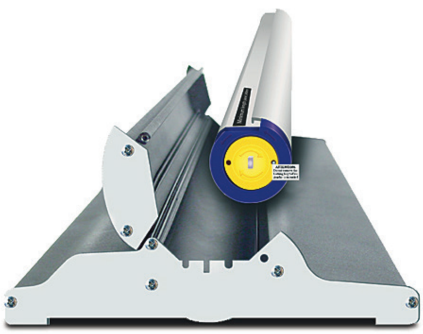


Fig. 7.2: In a roll-up system the print is ideally protected for transport.

Suitable printing techniques:

WATER BASED | SOLVENT | ECO SOLVENT | UV-CURABLE | LATEX

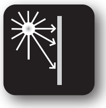
Recommended properties:

'No curling' print media tend not to curl at the sides and are therefore particularly suitable for hanging and banner applications. They are absolutely flat when hung.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

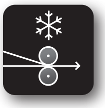
A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

Optional properties:

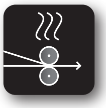


Print media with this symbol are opaque, i.e. nontransparent and block out light.

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.



Suitable for cold lamination: a self-adhesive film is laminated onto the printing material using rollers and protects the print from scratches, stains, moisture and UV radiation. The thickness of and adhesive used on the two materials to be bonded must be coordinated, otherwise blistering or curling may occur, i.e. the composite rolls in on each side. Prints with water-based ink should be overlapped when laminated to prevent moisture from penetrating at the edges.



Suitable for hot lamination: laminating film protects the print from scratches, stains, moisture and UV radiation. Hot laminate films do not have backing paper. The adhesive is thermally activated and applied under pressure, which creates a flat, level surface. The high temperatures would cause vinyl materials and prints with solvent-based inks to alter and/or melt. Hot lamination is best suited for the protection of water-based prints.

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

A largely crease-resistant textile or non-woven fabric withstands handling during production, assembly, transport and when an application is being used, without being damaged.

7.2 Folding Partitions | PopUp Display Systems

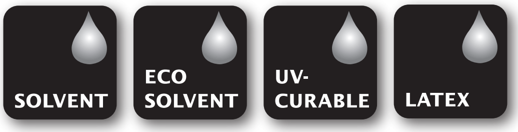
Photos: Expolinc AB

Fig. 7.3: Typical PopUp-Display

Portable pop-up or folding displays are often used as trade show partitions or advertising partitions at the POS (Point of Sale) and can be assembled and disassembled rapidly. Printed sheets are attached to magnetic rails on a folding, thin aluminium frame. The lightweight and robust space-saving design can be stowed in a transport box.
The surface of the print media should be protected with an additional film for this application because it is subjected to considerable wear due to frequent assembly and disassembly.

Fig. 7.4: Left: The components can be stowed in a transport box: folding frame, magnetic rails, lighting. Right: Foldable and light: the aluminium frame.

Suitable printing techniques:

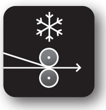


Recommended properties:

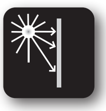
'No curling' print media tend not to curl at the sides and are therefore particularly suitable for hanging and banner applications. They are absolutely flat when hung.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.



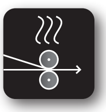
Suitable for cold lamination: a self-adhesive film is laminated onto the printing material using rollers and protects the print from scratches, stains, moisture and UV radiation. The thickness of and adhesive used on the two materials to be bonded must be coordinated, otherwise blistering or curling may occur, i.e. the composite rolls in on each side. Prints with water-based ink should be overlapped when laminated to prevent moisture from penetrating at the edges.



Print media with this symbol are opaque, i.e. nontransparent and block out light. You can use two measurements; one on white backing and one on black backing. A material is opaque when both readings match.

Optional properties:

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.



Suitable for hot lamination: laminating film protects the print from scratches, stains, moisture and UV radiation. Hot laminate films do not have backing paper. The adhesive is thermally activated and applied under pressure, which creates a flat, level surface. The high temperatures would cause vinyl materials and prints with solvent-based inks to alter and/or melt. Hot lamination is best suited for the protection of water-based prints.

7.3 Soft Image Display System | Textile Folding Display

Photos: Expolinc AB

Fig. 7.5: A typical soft signage display.

A textile graphic is attached to a folding lattice structure to create a portable and very light trade show or advertising wall. Since the textile remains on the system when it is folded, the display is assembled or disassembled in seconds. There are no components that can be lost.

Replacing the graphic is uncomplicated: the attached print is removed from the frame and a new print attached. Suitable print media for a textile folding display should be crease-resistant.

Fig. 7.6: The textile graphic remains on the lattice frame during transport and is thus quick to assemble and disassemble.

Suitable printing techniques:

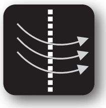
- DYESUB
- SOLVENT
- ECO SOLVENT
- LATEX

Suitable properties:

A largely crease-resistant textile or non-woven fabric withstands handling during production, assembly, transport and when an application is being used, without being damaged.

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.



Air-permeable print media are used for large formats in order to reduce wind load.

Optional properties:

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

7.4 Hanging Banners

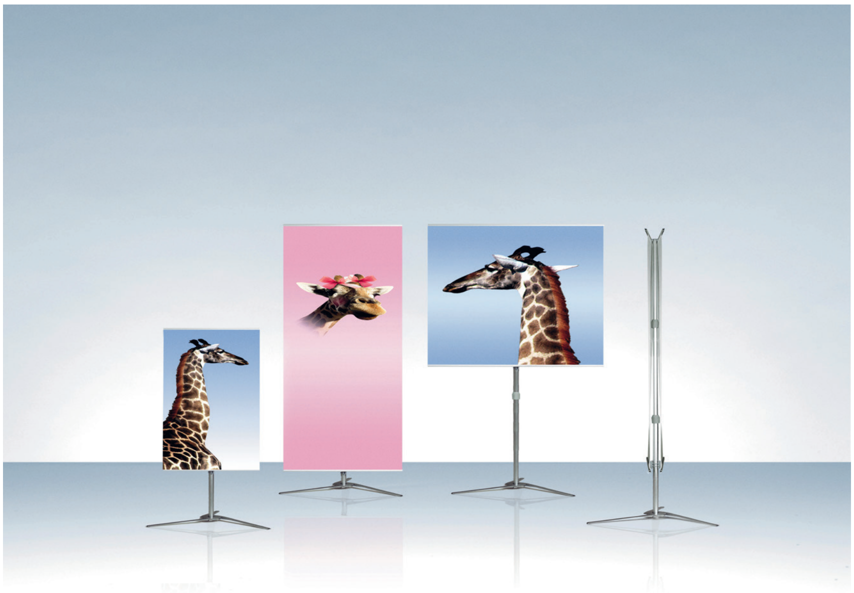


Fig. 7.7: A typical hanging banner.

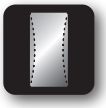
Banners for indoor applications which are hung are, for example, wall or ceiling mounted and used on display systems with clamping rails. Film or textile printing media can be used. It is advisable to use media that tend not to curl, i.e. roll in at the sides, and are straight when hung.

Fig. 7.8: Mount panel, set telescopic rod to the desired height – done.

Suitable printing techniques:

WATER BASED | DYESUB | SOLVENT | ECO SOLVENT | UV-CURABLE | LATEX

Recommended properties:



'No curling' print media tend not to curl at the sides and are therefore particularly suitable for hanging and banner applications. They are absolutely flat when hung.

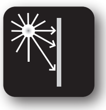
A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

Optional properties:

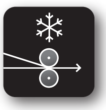
Print media with this symbol are PVC-free. Low-emission materials should be used in the home environment. PVC materials are not only problematic in terms of disposal, the plasticizers can also pollute the indoor air.

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.

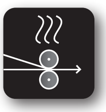


Print media with this symbol are opaque, i.e. nontransparent and block out light. You can use two measurements; one on white backing and one on black backing. A material is opague when both readings match.

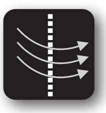
Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.



Suitable for cold lamination: a self-adhesive film is laminated onto the printing material using rollers and protects the print from scratches, stains, moisture and UV radiation. The thickness of and adhesive used on the two materials to be bonded must be coordinated, otherwise blistering or curling may occur, i.e. the composite rolls in on each side. Prints with water-based ink should be overlapped when laminated to prevent moisture from penetrating at the edges.



Suitable for hot lamination: laminating film protects the print from scratches, stains, moisture and UV radiation. Hot laminate films do not have backing paper. The adhesive is thermally activated and applied under pressure, which creates a flat, level surface. The high temperatures would cause vinyl materials and prints with solvent-based inks to alter and/or melt. Hot lamination is best suited for the protection of water-based prints.



Air-permeable print media are used for large formats in order to reduce wind load.

7.5 Backlit Advertising

Fig. 7.9: Typical backlit applications.

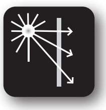
Light boxes or backlit display systems also convey your advertising message at nighttime. The backlighting of the print can intensify its brilliant effect.

Suitable print media include backlit film and banners or textiles with good scattering properties that can be used indoors and outdoors. It is important that the material can absorb a reasonable amount of ink and that optimal colour saturation can be achieved.

Media with an adhesive backing are particularly well suited for fixing at the POS, for example, on windows, glass doors or the Plexiglas inlays of light boxes.

Suitable printing techniques:

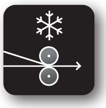
Recommended properties:



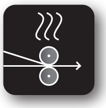
A semi-transparent film is the basis for a clear, brilliant print image with even light scattering and is therefore suitable for backlit applications.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

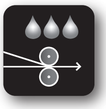
A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.



Suitable for cold lamination: a self-adhesive film is laminated onto the printing material using rollers and protects the print from scratches, stains, moisture and UV radiation. The thickness of and adhesive used on the two materials to be bonded must be coordinated, otherwise blistering or curling may occur, i.e. the composite rolls in on each side. Prints with water-based ink should be overlapped when laminated to prevent moisture from penetrating at the edges.



Suitable for hot lamination: laminating film protects the print from scratches, stains, moisture and UV radiation. Hot laminate films do not have backing paper. The adhesive is thermally activated and applied under pressure, which creates a flat, level surface. The high temperatures would cause vinyl materials and prints with solvent-based inks to alter and/or melt. Hot lamination is best suited for the protection of water-based prints.



Suitable for liquid lamination: a layer of varnish protects the print from scratches, stains, moisture and UV radiation. Liquid laminate protective coatings are typically water or solvent-based, which are applied manually (by brush or roller) or with a liquid lamination machine. In the case of eco-solvent prints, attention should be paid to the suitability of the varnish. Most eco-solvent inks contain an additive that affects the adhesion of unsuitable varnish.

Optional properties:

Weatherproof print media are waterproof, UV-resistant, oil-resistant, dirt-resistant and temperature-resistant; therefore, they are suitable for long-term to continuous use during the specified service life.

7.6 Flags

Fig. 7.10: A typical flag.

The base material for flags and banners is air-permeable textiles (woven) and 100% through-printing is sought. The prints may be used indoors and outdoors. For use outdoors, high UV resistance and weather resistance are important.

Fig. 7.11: Depending on the size and application of the flag, an X-foot, ground anchors, base filled with water or sand, or a metal base plate are suitable for erecting safely.

Suitable printing techniques:

SOLVENT | ECO SOLVENT | DYESUB

Recommended properties:

'No curling' print media tend not to curl at the sides and are therefore particularly suitable for hanging and banner applications. They are absolutely flat when hung.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

A largely crease-resistant textile or non-woven fabric withstands handling during production, assembly, transport and when an application is being used, without being damaged.

Optional properties:

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

Weatherproof print media are waterproof, UV-resistant, oil-resistant, dirt-resistant and temperature-resistant; therefore, they are suitable for long-term to continuous use during the specified service life.

Further properties:

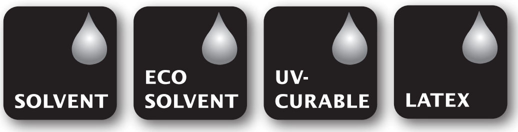
For colour measurements it is recommended to use self backing. In other words use as many layers (comprising the same image content) as needed that any aditional layer won't change the reading anymore.

7.7 Facade Banners

Fig. 7.12: Typical facade banners.

Large format outdoor banners are usually mounted on facades or scaffolding. They are printed in lengths of up to 5 m and if necessary placed side by side. Seams are stitched or eyelets attached (usually with reinforcing strips) for mounting. In the case of very large banners and depending on the degree of wind load, air-permeable mesh material should be used. Weather resistance and UV resistance are very important criteria for facade banners. If the banner is fixed to a building, the use of flame-retardant material is required by law. Due to the large viewing distance of a facade or scaffold banner, the resolution of the image data can be reduced significantly in order to avoid an overwhelming amount of data. The edge of the banner should not contain important elements, because eyelets/seams are placed there.

Suitable printing techniques:

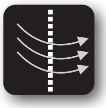


Recommended properties:

To fix outdoor banners on scaffolding, fences, or the like, an inkjet print is mounted using eyelets and braced.

Using hot-air or high frequency welding, lengths of material can be connected permanently and therefore any format – far beyond the maximum print width – is achievable. Hot-air welding is more favorable; however, more robust seams can be produced with high-frequency welding equipment.

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.



Air-permeable print media are used for large formats in order to reduce wind load.

Weatherproof print media are waterproof, UV-resistant, oil-resistant, dirt-resistant and temperature-resistant; therefore, they are suitable for long-term to continuous use during the specified service life.

A largely crease-resistant textile or non-woven fabric withstands handling during production, assembly, transport and when an application is being used, without being damaged.

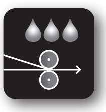
Highly tear-resistant print media are coated fabrics which withstand the highest stresses.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

Optional properties:

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.



Suitable for liquid lamination: a layer of varnish protects the print from scratches, stains, moisture and UV radiation. Liquid laminate protective coatings are typically water or solvent-based, which are applied manually (by brush or roller) or with a liquid lamination machine. In the case of eco-solvent prints, attention should be paid to the suitability of the varnish. Most eco-solvent inks contain an additive that affects the adhesion of unsuitable varnish.

7.8 Truck Tarpaulins

Fig. 7.13: A typical truck tarpaulins.

Truck tarpaulins are a coated fabric, which must be extremely tear-proof, waterproof, weatherproof and very durable. The print must also be UV-resistant. The tarpaulins can be welded, stitched and fitted with eyelets for processing. Every format – far beyond the maximum print width – can be produced by welding and thus permanently connecting the individual print lengths.
There are two methods: hot-air or high frequency welding. Hot-air welding is more favourable; however, more robust seams can be produced with high-frequency welding equipment. Lamination with varnish (liquid lamination) can be used as a surface sealant for truck tarpaulins.

Suitable printing techniques:

- SOLVENT
- ECO SOLVENT
- UV-CURABLE

Recommended properties:

Using hot-air or high frequency welding, lengths of material can be connected permanently and therefore any format – far beyond the maximum print width – is achievable. Hot-air welding is more favorable; however, more robust seams can be produced with high-frequency welding equipment.

Weatherproof print media are waterproof, UV-resistant, oil-resistant, dirt-resistant and temperature-resistant; therefore, they are suitable for long-term to continuous use during the specified service life.

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

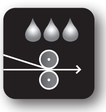
To fix outdoor banners on scaffolding, fences, or the like, an inkjet print is mounted using eyelets and braced.

Durable, air-impermeable print media.

Highly tear-resistant print media are coated fabrics which withstand the highest stresses.

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

Optional properties:



Suitable for liquid lamination: a layer of varnish protects the print from scratches, stains, moisture and UV radiation. Liquid laminate protective coatings are typically water or solvent-based, which are applied manually (by brush or roller) or with a liquid lamination machine. In the case of eco-solvent prints, attention should be paid to the suitability of the varnish. Most eco-solvent inks contain an additive that affects the adhesion of unsuitable varnish.

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.

7.9 Car Wrapping

Fig. 7.14: Typical car wrapping applications.

Car wrappings are exposed to the weather; therefore, their quality must be correspondingly high. For optimal processing, they should also be flexible and tear-resistant.
Car wrappings are made of PVC (polyvinyl chloride), which is a brittle, hard plastic that is made flexible by adding plasticizers. Crucial to the durability of the film (also to the price) is the type of plasticizer used and the manufacturing process. PVC films can be produced relatively simply and inexpensively using a system of rollers (calender) or cast - a complicated and therefore more expensive method that produces high-quality products.

Suitable printing techniques:

SOLVENT | ECO SOLVENT | UV-CURABLE | LATEX

Car wrapping films are practically categorized according to their base material and the associated (estimated) shelf life:

"3-year film"

For flat surfaces, such as a logo on the (smooth) side of a van.

Material: monomeric plasticized PVC, calendered.

Monomeric calendered films are intended for short term use. The monomeric plasticizer evaporates relatively quickly, especially when heated. This leads to shrinkage, which may cause the film to tear. Calendered films are inexpensive; however, depending on the manufacturer their service life is limited to up to three years. Since calendered films possess a kind of memory effect and return to their original form, they are suitable mainly for use on smooth and level surfaces.

"5-year film"

For level and curved surfaces, such as a logo on a slightly rounded hood.
Material: polymeric plasticized PVC, calendered.

Polymeric calendered films are designed for medium-term use. The plasticizer evaporates much less and the film remains supple for longer. Since calendered films possess a kind of memory effect and return to their original form, they are suitable mainly for use on smooth and level surfaces.

"7-year film"

For flat and curved surfaces, beading, corners, edges, e.g. complete car wrapping.

Material: polymeric plasticized PVC, cast.

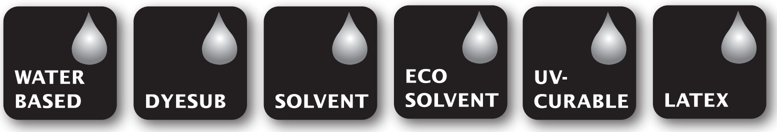
Cast films are weatherproof and designed for long-term use. Their shrinkage properties are minimal, they are suitable for 3D wrapping and they have no memory effect.

7.10 Sunshades

Fig. 7.15: Typical sunshade applications.

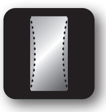
Individually printable blind and sunshade materials are exposed to considerable stresses. Good scratch-resistance and a high degree of light-fastness are indispensable. The materials are coated on both sides and possess good hanging stability. The print medium used for a blind application should hang very straight and must not curl at the edges even after long use.
As with all permanent applications for interior spaces, attention should be paid to selecting a PVC-free material for the media since doing so will prevent the indoor air from becoming polluted. A barrier layer which blocks UV radiation is required for use as a sunshade.

Suitable printing techniques:



Recommended properties:

Print media with this symbol are PVC-free. Low-emission materials should be used in the home environment. PVC materials are not only problematic in terms of disposal, the plasticizers can also pollute the indoor air.



'No curling' print media tend not to curl at the sides and are therefore particularly suitable for hanging and banner applications. They are absolutely flat when hung.

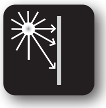
A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

Optional properties:

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.



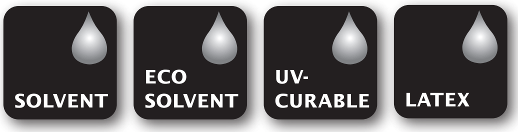
Print media with this symbol are opaque, i.e. nontransparent and block out light. You can use two measurements; one on white backing and one on black backing. A material is opaque when both readings match.

7.11 Wallpaper

Fig. 7.16: Typical wallpaper applications.

Individually printable wallpapers offer many new possibilities for wall design, both in private homes and in commercial spaces: logo wallpaper for walls in the corporate design, with its own motives and photos ...
They differ from printed panels or braced prints with their special surface, tactile properties and simple processing. Digitally printable wallpaper can have either a smooth surface or be embossed. For printable wallpaper, as with all materials intended for long-term use in the home environment attention should be paid that they are open to diffusion, PVC-free and thus guarantee a good indoor climate.

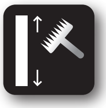
Suitable printing techniques:



Recommended properties:

Print media with this symbol are PVC-free. Low-emission materials should be used in the home environment. PVC materials are not only problematic in terms of disposal, the plasticizers can also pollute the indoor air.

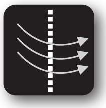
A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.



The wall adhesion technique makes it particularly easy for the user. A high-quality, dimensionally stable non-woven wallpaper need not be laid out and pasted, but can be placed directly on a wall that has been treated with standard non-woven fabric adhesive. Since dispersion adhesive is not used, the wallpaper can be stripped in a dry state in the event of a renovation.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.



Air-permeable print media are used for large formats in order to reduce wind load.

7.12 Art reproduction

Fig. 7.17: Typical Art reproductions.

Art reproductions look best on a material that comes close to the original canvas. Coated canvas media have a linen-like, textured surface yet still guarantee a sharp print.
A digitally printed canvas can be mounted on a classic wedge frame made of wood. A suitable medium must not tear or fray when stapled and should be flexible and durable.
Even more print media, non-woven fabrics for example, are suitable for modern clamping frame systems made of aluminium, since it is possible to mount on these without using staples. Changing the image is very simple and straightforward. With very light but durable aluminium profiles, it is not possible for the frame to distort. Almost all flexible printing media (canvas, textiles, non-woven fibre fabrics, wallpaper) are suitable for such an application. In terms of fire protection, the modern clamping system made of aluminium is far superior to its combustible colleagues made of wood when a flame-retardant print medium is used. Stapling is not necessary with modern clamping systems made using aluminium. The image is glued and secured with clips and supporting wedges.

Fig. 7.18: A material with a canvas structure is used for many art reproductions.

Suitable printing techniques:

WATER BASED | DYESUB | SOLVENT | ECO SOLVENT | UV-CURABLE | LATEX

Recommended properties:

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

Optional properties:

Print media with this symbol are PVC-free. Low-emission materials should be used in the home environment. PVC materials are not only problematic in terms of disposal, the plasticizers can also pollute the indoor air.

A largely crease-resistant textile or non-woven fabric withstands handling during production, assembly, transport and when an application is being used, without being damaged.

Suitable for liquid lamination: a layer of varnish protects the print from scratches, stains, moisture and UV radiation. Liquid laminate protective coatings are typically water or solvent-based, which are applied manually (by brush or roller) or with a liquid lamination machine. In the case of eco-solvent prints, attention should be paid to the suitability of the varnish. Most eco-solvent inks contain an additive that affects the adhesion of unsuitable varnish.

When used at trade shows, public buildings, or the like, a print medium with flame retardant treatment should be used.

7.13 Posters

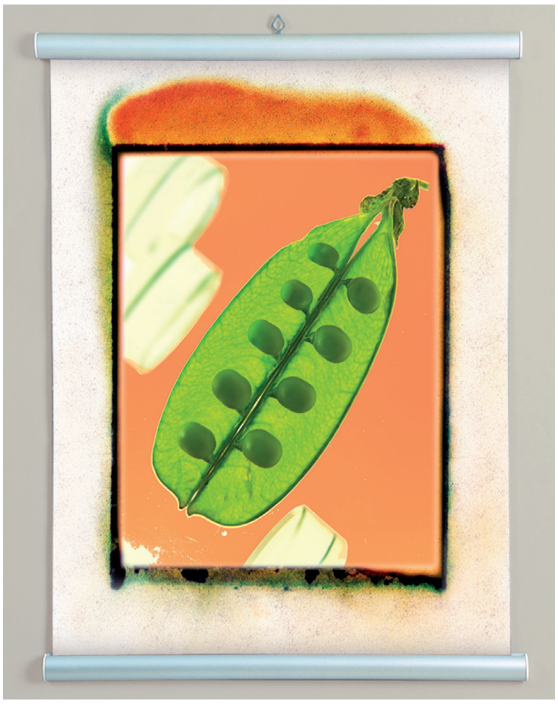
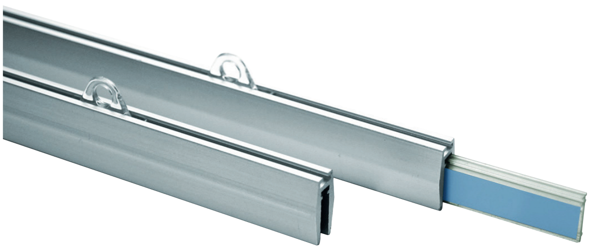


Fig. 7.19: A typical poster application.

Amongst other things, posters are used in poster frames, folding frames or as customer stoppers. High resolution, brilliant inks and good protection against mechanical stress and colour fading are the most important criteria for poster printing.
In general, the largest colour space can be achieved with water-based inks. Surface protection is very important in order to achieve an enduring print.



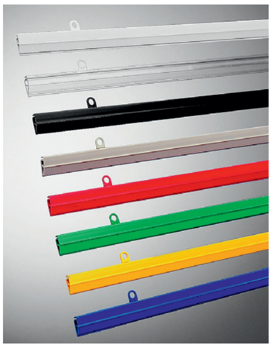
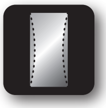


Fig. 7.20: Poster profiles are available in various colours and can be reused.

Suitable printing techniques:

Recommended properties:

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

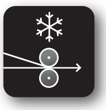


'No curling' print media tend not to curl at the sides and are therefore particularly suitable for hanging and banner applications. They are absolutely flat when hung.

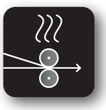
A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

Optional properties:



Suitable for cold lamination: a self-adhesive film is laminated onto the printing material using rollers and protects the print from scratches, stains, moisture and UV radiation. The thickness of and adhesive used on the two materials to be bonded must be coordinated, otherwise blistering or curling may occur, i.e. the composite rolls in on each side. Prints with water-based ink should be overlapped when laminated to prevent moisture from penetrating at the edges.



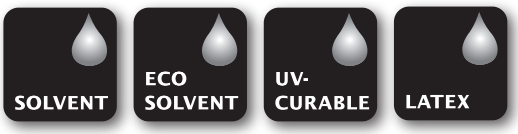
Suitable for hot lamination: laminating film protects the print from scratches, stains, moisture and UV radiation. Hot laminate films do not have backing paper. The adhesive is thermally activated and applied under pressure, which creates a flat, level surface. The high temperatures would cause vinyl materials and prints with solvent-based inks to alter and/or melt. Hot lamination is best suited for the protection of water-based prints.

7.14 Book Cover

Fig. 7.21: Typical book covers.

Individually printable book cover fabrics are indispensable in the book-on-demand segment. These materials offer the possibility to furnish individually-made books with a standard durable cover. Specially refined surfaces make for good print quality and detail reproduction as well as good scratch-resistance and abrasion-resistance. For good adhesion and glue dense processing, it is important to ensure that the reverse side of the cover material is appropriately furnished.

Suitable printing techniques:



Recommended properties:

Print media with this symbol can be very easily cut when cold. Materials without this symbol are more complicated and should be cut with a hot cutter.

A largely scratch-resistant print medium withstands handling during production, assembly, transport and when an application is being used, without being damaged. Additional surface protection (laminate) increases durability.

A print medium that thoroughly dries quickly can be processed faster. That is important for an optimized workflow, for example, when printing, laminating, cutting, assembling and packing.

Print media with this symbol are PVC-free. Low-emission materials should be used in the home environment. PVC materials are not only problematic in terms of disposal, the plasticizers can also pollute the indoor air.

8 PSD-Certification

8.1 Certification according to the PSD requirements

The Process Standard Digital (PSD) was developed by Fogra. It is the description of an industrially orientated and standardized procedure for the creation of digital print products. Using the PSD certificate, service providers can show their quality approach and their overall understanding of the output processes. Successful implementation of the PSD provides printers with the benefits of improved cost, quality and time performance, with better sustainability and reduced waste.

General Prerequisites

¬ Hardware: Handheld colour measuring device including a means for drift detection (exemplary evaluation)

¬ Software: PDF- and EPS-based colour transforms, data preflight using PDF/X-Ready profiles, Fogra MediaWedge CMYK V3.0

Identification of 3 "combinations"

Each to be certified company has to identify three combinations (i.e. setup of substrate, printer, print mode and driving) for the one day audit. Those three combinations should comprise of typical setups for the print shop and different printers unless there is only one machine used. In that case the combinations might differ in another component such as the substrate or screening. Please use the provided spreadsheet to specify the three combinations. It also contains examples.

If the print shop does not use a proof/printer combination separate from these three production print combinations for creating references according to ISO 12647-7 (contract proof) or ISO 12647-8 (validation print), a reference in full compliance to either one of these standards has to be printed using one of this three combinations.

Recommended tests:

¬ Successful completion of PDF/X-Creation

¬ Successful completion of PDF/X-Output for one of the three combinations

¬ Successful completion of FograCert Validation Print Creation for one of the three combinations or Contract Proof Creation or PSOprepress certification respectively

¬ ISO 3664 conforming viewing environment (by means of: FograCert Viewing Cabinet or ISO 3664 conformance protocol of the manufacturer)

Conducting these certifications is not obligatory in regards to the PSD certification. However we strongly recommend to conduct these tests in order to analyze potential gaps and ways to improve them ahead of time. In any case, the individual aspects and their compliance with PSD will be tested during the audit.

On-site checks:

¬ **Output process control:**

1. Quality management: Usage of methods for periodical process control (at least for the three combinations) - based on the Fogra MediaWedge V3.
2. Monitoring: Usage of quality assurance means to report and analyze the drift (at least for the three combinations)
3. Calibration (against a reference): Means for correcting and corrective action in order to repeatably achieve the ground state (at least for the three combinations)

¬ **Colour Fidelity:**

1. Print output according to draft ISO/TS 15311-2 or -3 against a reference printing condition (for the three combinations)
2. The chosen combinations and quality levels will be listed on the Fogra webpage.

¬ **Workflow:**

1. Light-audit: Scrutiny of (at least) one viewing condition where colour critical appraisal is possible (ISO 3664)
2. Preflight: Finding 7 out of 10 errors in a PDF file that will be sent to you two weeks before the audit
3. PDF/X creation: Compliant PDF/X-Creation
4. PDF/X output: Consistent PDF/X-processing and -output
5. Altona Test Suite: Understanding the gist of the important elements and raise awareness for potential limitations of the used workflows (to be checked for the three combinations).
6. Profile-handling: Configuring and conducting a PDF colour transformation of a RGB-based office PDF toward a selectable reference printing condition (e.g. FOGRA39).
7. Know-how: Print and separation related analyzis of one of the three combinations (by means of the preferred tone value sum, separation strategy, variability, achievable gamut etc).

Checklist – An overview

Fig. 8.1: How to get the Fogra PSD certification.

You can also download the checklist from the webpage.

8.2 Checklist – PSD Certification

Introduction

The following tables are intended for preparing you for certification according to Fogra PSD. The necessary prerequisites are marked with “shall”. In addition we kindly ask you to provide information that is also important but not normative (“should”) and helps us preparing for the certification audit at your premises. The checklist might also be used for your internal quality measurement means regarding the professional communication of colour. An important component of the PSD-certification is the identification of three representative system combinations. These are combinations (“combis”) of RIP, printing system, print mode and the substrate, which are typical for your daily production. The list also covers the type of colour appraisal namely Side-by-Side or media relative. This is important because it influences the type of evaluation. The three combinations selected by you build the basis for both the printing related and data related analysis during and after the audit.

Please fill out the tables properly and then send it to Fogra. Please also name the contact person being responsible for the organisational handling of the certification. We will then contact you.

Recommended certifications (FograCert)

Requirement	Certification	FograCert No. (expert opinion)	Date of certification and expiration:
Should	Successful completion of PDF/X-Creation		
Should	Successful completion of PDF/X-Output for one of the three combinations		
Should*	Successful completion of FograCert Validation Print Creation or Contract Proof Creation for one of the three combinations		

Tab. 8.1: Required certifications. All certifications muss be valid during the period of the audit must be scheduled.
**: If you are already using a proofing system that is certified according to FograCert CPC or FograCert VPC this requirement is considered as fulfilled.*

Devices

Requirement	Task	Name of device	Last maintained / Expiration:
Shall	Handheld colour measurement device (45°:0° or 0°/45° geometry)		
Shall	Means to identify drifts of the measurement devices (e.g. Ceramics, X-Rite Netprofiler, Techkon SpectroCheck, individual light- and scratch resistant samples)		
Shall	ISO 3664 conforming viewing environment (by means of: FograCert Viewing Cabinet or ISO 3664 conformance protocol of the manufacturer)		

Tab. 8.2: Devices that are required to be present (and in use).

Used Software (packages)

Require-ment	Used Software	In use (Name)	Remarks
Shall	Quality management software		
Should	Adobe Acrobat Pro		
Shall*	PDFX-ready Preflight Profiles V2 www.pdfx-ready.ch		

Tab. 8.3: Needed or recommended software programs. The PDF/X-ready V2 profiles might not be available for all workflows. If there are no profiles for your workflow, you won't need them.

Control wedges

Require-ment	Control wedge	In use?	Remarks
Shall*	Fogra MediaWedge CMYK V3, Fogra Media-Wedge Multicolor V1 for ECG based reference printing conditions.		
Should	Further wedges		

Tab. 8.4: Needed control wedges. We recommend to use the MediaWedge V3.

Identification of 3 representative system combinations

According to Fig. 8.1 you submit the overview of the three combinations at a later time. However we kindly ask you to think about which combinations to use. You should also check those combinations against the requirements defined in ISO/TS 15311-2 and ISO/TS 15311-3 respectively.

Require-ment	Task	Prepared?	Further questions?
Shall	Fill out form of combinations		

Tab. 8.5: Identification of three typical, i. e. representative combinations

General Information

Quality management can be considered to have four main components: quality planning, quality control, quality assurance and quality improvement. Quality management is focused not only on product/service quality, but also on the means to achieve it. With this in mind, we ask you to write down the following information about your company organization and the available/used equipment. In cases where standard operating procedures (SOPs) as required in ISO 9001 are available, please comment appropriately.

Information regarding the business organization

Task	Responsible person	Remarks
Job preparation		
Workflow		
Data acceptance and preflight		
Material check		
Printer calibrations		
Quality assurance		
Continuing Education		
Logistics		
Customer satisfaction		

Tab. 8.6: Information regarding the business organization.

Available literature

Literature	In Use (PDF or Print out)	Remarks
GWG Output Suite manual		
Altona Test Suite (ATS V1 und V2) Documentation		
Fogra Softproof Handbook V1-		
Further literature		
Articles at: https://fogra.org/en/downloads/work-tools/expert-knowledge-colour		
Subscription of Mailing-lists (ECI, DPWG)		
ISO Standards		

Tab. 8.7: Available literature.

Available digital test form packages

Package	In Use (PDF or Print out)	Remarks
GWG (Ghent Working Group) test forms		
Excel Spreadsheet: ISO 3664 Evaluation using handheld devices		
Altona Test Suite V.1 and V.2		
Roman 16 reference images		
Fogra digital print test forms*		
Further?		

*Tab. 8.8: Available test packages. * All test forms and work tools can be downloaded at https://fogra.org/en/certification/digital-printing/psd*

8.3 PSD tolerance: Historic overview

The PSD tolerances were first published in 2011. With the edition of the PSD 2016 Handbook, the tolerance values have been further refined. Two years later, the PSD 2018 handbook was issued alongside slightly modified the tolerances. All PSD tolerances are summarized in this section. It should be noted that the following tolerances are already deprecated.

Tolerance schema: "PSD 2011"

¬ OK-Sheet: Side-by-Side Evaluation

PSD-Absolute tolerances:

Patch in digital printing form	Quality Type C	Quality Type B	Quality Type A
Substrate	$\Delta E_{00} < 4.0$	$\Delta E_{00} < 3.0$	$\Delta E_{00} < 2.0$
All patches	Maximum $\Delta E_{00} < 8.0$ Average $\Delta E_{00} < 4.0$	Maximum $\Delta E_{00} < 7.0$ Average $\Delta E_{00} < 3.0$	Maximum $\Delta E_{00} < 6.0$ Average $\Delta E_{00} < 2.0$
Grey Balance patches	Average $\Delta C_h \leq 4.5$	Average $\Delta C_h \leq 3.5$	Average $\Delta C_h \leq 2.5$

Reproduction of Spot Colours:

	Quality Type C	Quality Type B	Quality Type A
Maximum colour difference	$\Delta E_{00} < 5.0$	$\Delta E_{00} < 3.0$	$\Delta E_{00} < 2.0$

¬ OK-Sheet: Media Relative Evaluation

Check whether a media relative evaluation is applicable:

	Black point difference	White Point difference
Tolerance Quality A	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 3.0	ΔE_{00} (Ref_paper, Act_paper) < 5.0
Tolerance Quality B	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 10.0	ΔE_{00} (Ref_paper, Act_paper) < 7.0
Tolerance Quality C	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 15.0	ΔE_{00} (Ref_paper, Act_paper) < 10.0

PSD-Media Relative tolerances:

Patches in digital printing form	Quality Type C	Quality Type B	Quality Type A
All Patches	Average $\Delta E_{00} < 4.0$ 95% Quantile $\Delta E_{00} <$ 10.0	Average $\Delta E_{00} < 2.5$ 95% Quantile $\Delta E_{00} <$ 7.0	Average $\Delta E_{00} < 1.5$ 95% Quantile $\Delta E_{00} <$ 5.0

There is no media-relative evaluation for the reproduction of spot colours.

¬ Stability within the print run

Tolerances:

	Quality Type C	Quality Type B	Quality Type A
CMYKRGB, 50 % CMYK	max (95% quantile ΔE_{00}) < 7.0	max (95% quantile ΔE_{00}) < 5.0	max (95% quantile ΔE_{00}) < 3.0

Tolerance schema: "PSD 2016"

¬ OK-Sheet: Side-by-Side Evaluation

PSD-Absolute tolerances:

Patch in digital printing form	Quality Type C	Quality Type B	Quality Type A
Substrate	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 3.5$
All patches	Average $\Delta E_{00} < 5.5$ 95% Quantile $\Delta E_{00} < 6.5$	Average $\Delta E_{00} < 4.5$ 95% Quantile $\Delta E_{00} < 5.5$	Average $\Delta E_{00} < 2.5$ 95% Quantile $\Delta E_{00} < 4.5$
Grey Balance patches*	Maximum $\Delta C_h \leq 5.5$	Maximum $\Delta C_h \leq 4.5$	Maximum $\Delta C_h \leq 3.5$

Reproduction of Spot Colours:

	Quality Type C	Quality Type B	Quality Type A
Maximum colour difference	$\Delta E_{00} < 5.5$	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 2.5$

¬ OK-Sheet: Media Relative Evaluation

Check whether a media relative evaluation is applicable:

	Black point difference	White Point difference
Tolerance Quality A	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 3.5	ΔE_{00} (Ref_paper, Act_paper) < 6.5
Tolerance Quality B	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 10.5	ΔE_{00} (Ref_paper, Act_paper) < 8.5
Tolerance Quality C	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 15.5	ΔE_{00} (Ref_paper, Act_paper) < 11.5

PSD-Media Relative tolerances:

Patches in digital printing form	Quality Type C	Quality Type B	Quality Type A
All Patches	Average $\Delta E_{00} < 6.5$ 95% Quantile $\Delta E_{00} < 8.5$	Average $\Delta E_{00} < 4.5$ 95% Quantile $\Delta E_{00} < 6.5$	Average $\Delta E_{00} < 2.5$ 95% Quantile $\Delta E_{00} < 4.5$
Grey Balance patches*	Maximum $\Delta C_h \leq 4.5$	Maximum $\Delta C_h \leq 3.5$	Maximum $\Delta C_h \leq 2.5$

There is no media-relative evaluation for the reproduction of spot colours.

¬ Stability within the print run

Tolerances:

	Quality Type C	Quality Type B	Quality Type A
CMYKRGB, 50 % CMYK	max (95% quantile ΔE_{00}) < 5.5	max (95% quantile ΔE_{00}) < 3.5	max (95% quantile ΔE_{00}) < 1.5

Tolerance schema: "PSD 2018"

¬ OK-Sheet: Side-by-Side Evaluation

PSD-Absolute tolerances:

Patch in digital printing form	Quality Type C	Quality Type B	Quality Type A
Substrate	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 3.5$
All patches	Average $\Delta E_{00} < 5.5$ 95% Quantile $\Delta E_{00} < 6.5$	Average $\Delta E_{00} < 4.5$ 95% Quantile $\Delta E_{00} < 5.5$	Average $\Delta E_{00} < 2.5$ 95% Quantile $\Delta E_{00} < 4.5$
Grey Balance patches*	Maximum $\Delta C_h \leq 4.5$	Maximum $\Delta C_h \leq 3.5$	Maximum $\Delta C_h \leq 2.5$

Reproduction of Spot Colours:

	Quality Type C	Quality Type B	Quality Type A
Maximum colour difference	$\Delta E_{00} < 5.5$	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 2.5$

¬ OK-Sheet: Media Relative Evaluation

Check whether a media relative evaluation is applicable:

	Black point difference	White Point difference
Tolerance Quality A	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 3.5	ΔE_{00} (Ref_paper, Act_paper) < 6.5
Tolerance Quality B	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 10.5	ΔE_{00} (Ref_paper, Act_paper) < 8.5
Tolerance Quality C	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 15.5	ΔE_{00} (Ref_paper, Act_paper) < 11.5

PSD-Media Relative tolerances:

Patches in digital printing form	Quality Type C	Quality Type B	Quality Type A
All Patches	Average $\Delta E_{00} < 6.5$ 95% Quantile $\Delta E_{00} < 8.5$	Average $\Delta E_{00} < 4.5$ 95% Quantile $\Delta E_{00} < 6.5$	Average $\Delta E_{00} < 2.5$ 95% Quantile $\Delta E_{00} < 4.5$
Grey Balance patches*	Maximum $\Delta C_h \leq 4.5$	Maximum $\Delta C_h \leq 3.5$	Maximum $\Delta C_h \leq 2.5$

¬ There is no media-relative evaluation for the reproduction of spot colours.

¬ Stability within the print run

Tolerances:

	Quality Type C	Quality Type B	Quality Type A
CMYKRGB, 50 % CMYK	max (95% quantile ΔE_{00}) < 5.5	max (95% quantile ΔE_{00}) < 3.5	max (95% quantile ΔE_{00}) < 1.5

TIP: Ripping out this page provides you with a handy overview over all "PSD 2022" tolerances!

8.4 All PSD requirements: Current Tolerances " PSD-2022"

OK-Sheet: Side-by-Side Evaluation

¬ **Tolerances:**

Patch in digital printing form	Quality Type C	Quality Type B	Quality Type A
Substrate	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 3.5$
All patches	Average $\Delta E_{00} < 5.5$ 95% Quantile $\Delta E_{00} < 6.5$	Average $\Delta E_{00} < 4.5$ 95% Quantile $\Delta E_{00} < 5.5$	Average $\Delta E_{00} < 2.5$ 95% Quantile $\Delta E_{00} < 4.5$
Grey Balance patches*	Maximum $\Delta C_h \leq 4.5$	Maximum $\Delta C_h \leq 3.5$	Maximum $\Delta C_h \leq 2.5$
* ΔC_h is explained in chapter 2.3.			

¬ **Reproduction of Spot Colours:**

	Quality Type C	Quality Type B	Quality Type A
Maximum colour difference	$\Delta E_{00} < 5.5$	$\Delta E_{00} < 3.5$	$\Delta E_{00} < 2.5$

OK-Sheet: Media Relative Evaluation

¬ **Check whether a media relative evaluation is applicable:**

	Black point difference	White Point difference
Tolerance Quality A	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 6.5	ΔE_{00} (Ref_paper, Act_paper) < 6.5
Tolerance Quality B	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 10.5	ΔE_{00} (Ref_paper, Act_paper) < 8.5
Tolerance Quality C	|Act_Min_CIEL_Dark, Ref_Min_CIEL_Dark| < 15.5	ΔE_{00} (Ref_paper, Act_paper) < 11.5

¬ **Tolerances:**

Patches in digital printing form	Quality Type C	Quality Type B	Quality Type A
All Patches	Average $\Delta E_{00} < 6.5$ 95% Quantile $\Delta E_{00} < 8.5$	Average $\Delta E_{00} < 4.5$ 95% Quantile $\Delta E_{00} < 6.5$	Average $\Delta E_{00} < 2.5$ 95% Quantile $\Delta E_{00} < 4.5$
Grey Balance patches*	Maximum $\Delta C_h \leq 4.5$	Maximum $\Delta C_h \leq 3.5$	Maximum $\Delta C_h \leq 2.5$
* ΔC_h is explained in chapter 2.3.			

¬ There is no media-relative evaluation for the reproduction of spot colours.

Stability within the print run

¬ **Tolerances:**

	Quality Type C	Quality Type B	Quality Type A
CMYKRGB, 50% CMYK	Maximum (95% quantile ΔE_{00}) < 5.5	Maximum (95% quantile ΔE_{00}) < 3.5	Maximum (95% quantile ΔE_{00}) < 1.5