Material Efficiency for Image Output on Colour Printers

Prof. Dr. Klaus Richter, BAM and TU Berlin

Federal Institute for Materials Research and Testing (BAM)
Working Group VIII.34, Visual Methods and Image Reproduction

Unter den Eichen 87, D-12205 Berlin

Tel. +49 30 8104 1834; Fax +49 30 8104 1807

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klaus.richter@bam.de

http://www.ps.bam.de

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Abstract

By considering environmental aspects an efficient usage of ink and toner material for colour printers is proposed. For that goal a colorimetric reproduction method for printers is developed which maintains hue, relative chroma and relative lightness. This method is of special importance also for the display reproduction, for the print cost per page of consumers and for the long term storage of colours in documents (archiving of art work).

The proposals include the enlargement of research and development at the BAM and the TU Berlin to apply colorimetric (measurement based) image reproduction methods. In the key area “information technology” this leads to a necessary connection of standardization with research and development according to the DIN goal “The German Standardization Strategy 2004” [10]

1. Introduction

The BAM had taken a leading role in the development of the standards DIN 33870:2000 and 33871-1:2003 for toner and ink jet printers. Both standards got prices in the DIN-concurrence “Application of the Standardization”. These standards are the basic for the environmental label “Blue Angle (Blauer Engel)”. The following proposals lead to a usage of inkjet and toner material according to environmental requirements. For realisation about 10 new procedure and application standards are apropriate fto specify image reproduction properties in the information technology [8,9].

The Federal Environmental Agency (UBA) has supported methods for the measurement of emissions of colour printers and the CEN/BT/TF 165 for European Standards of remanufactured modules of black and white and colour printers. Up to now this support does not cover the economical, the environmental and the consumer friendly material usage which needs a colour image reproduction by black generation (at maximum two chromatic colours and black) or the reproduction as a grey image. For this new and additional supports are important.

2.Special economical importance

In 2003 the turnover of toner and inkjet cartridges (consumable) was about 7 billion Euro world wide with about one third in America, Asia and Europe. Under the six large manufacturers (HP, Canon, Lexmark, Epson, Minolta-Konika, Oki) HP is the leading manufacturer with 45%. In Europe there exists only one larger manufacturer (Oce in the Netherlands). About 20 European manufacturers are engaged in the refilling and the remanufacturing of cartridges and many produce according to DIN 33870 and DIN 33871-1.

3. Consumer requirement for Standardization and Protection of Environment

In 2002 the english institute “Office for Fair Trading” has studied the printer market [11]. This institute has urgently required international standards to calculate the cost per page. ISO/IEC 19752:2004 has used BAM-Know-How to

define the “yield” of black and white toner printers and this is a first step in this direction. An environmental and consumer friendly development with an improvement of material efficiency by a factor 3 by equal costs is in conflict with a corresponding turnover reduction of all manufacturers.

In some cases the refilling or the remanufacturing is prevented because electronic chips are included in the cartridges. In some cases printers including a set of cartridges are equal or nearly equal in price compared to a set of new cartridges. This leads in many cases to a new buy of millions of printers and to printer waste material. Additionally millions of cartridges lead to garbage.

4. User friendly colour coordinates and 16 step relative colour output

The consumers require user friendly colour coordinates for the description of the colours in information technology, which can be calculated from Lightness, Chroma and Hue of the **device independent *CIELAB*** colour system. Fig. 1 shows the calculation of equivalent (corresponding) colorimetric coordinates in 12 different colour systems, for example by the coordinates ***nce*** (relative blackness, chromaticness and elementary hue) of the Swedish Standard NCS (Natural Colour System). CIELAB cameras of the working group directly measure the CIELAB colour system data of the image pixels.

5. Environmental friendly usage of colour materials by black generation

Fig. 1 shows on the left right a dark red colour *Fa* in a hue triangle with Black (*Na*=Noir), White (*Wa*) and the Maximal colour Red (*Ma*). With colour printers grey colours may be mixed in chromatic generation from three chromatic colours (*C, M,* and *Y*) or by only black *(N)*. All colours may be mixed **either by black generation** (see Enclosure no. 8415 by *YM+N* to 8435 by *CY+N*) **or by chromatic generation** (see no. 8445 by *CMY*).

Some manufacturers deliver cartridges with a threefold more yield compared to colour cartridges. Black *N* is also in offset printing about threefold less expensive compared to the chromatic colours *CMY.* For the grey output the cost ratio between black and chromatic generation is therefore 1/9 = 0,11. According to the hue triangle in Fig. 1 the visual equal colour *Fa* may be mixed with black generation by 25% *(M+Y)* and 50% *N* or with chromatic generation by 63% *(M+Y)* and 50% *C*. The cost ratio between achromatic and chromatic generation is 0.24 = [25+(50/3)] / [126+50]. In general the costs of toner and ink jet materials are reduced to 1/3 if the black generation is used.

At present most of the printer systems (hardware including software) do not include the **black generation for the colour image reproduction (cost reduction 33%)** and additionally instead of colour image output the **option of grey image output (price reduction to 11%)** is missing which is often required by many consumers.

6. Standards for colour image reproduction

The BAM was leader in creating the standards DIN 33866-1 to -5: 2000 [3] for colour image reproduction properties of copiers, scanners, printers and monitors with digital and analog test charts. These standards include the user requirement for the output of 16 step equally spaced colour scales.

The author was editor of the International Standard for colour copiers (ISO/IEC 15775:1999) which has realized this user requirement. The user required scan of the 16 step test charts and the reproduction on monitors and printers according to DIN 33866-1 to 5:2000 (corresponds to ISO/IEC DIS 19739-X:2000) has been rejected internationally. However the standards DIN 33866-X:2000 have been accepted as International Technical Report ISO/IEC TR 24705:2005 [7]. By the view from the environment and the consumers the transfer of the standards DIN 33866-1 to 5 and the corresponding Technical Report ISO/IEC TR 24705:2005 to European Standards is proposed.

The Information Technology (IT) uses mostly *rgb*-colour coordinates (amounts of each colour in red, green and blue) which are completely non obvious for the users and confuse them very much. For the four colour printer output and by colorimetry the *rgb*-coordinates can be transferred to output required *cmyn**-coordinates which are similar non obvious.

BAM VIII.34 has developed filters which allow for PDF files (ISO Standard for archiving) equal output for 12 equivalent colour coordinates. In application the IT industry produces for equivalent coordinates *rgb* and *cmy* – especially since introduction of “colour management” in the computer operating systems Windows and Mac since 2002 – completely different colour outputs on any colour printer and any monitor.

For colours defined in equivalent *rgb* and *cmy* colorimetric coordinates the BAM-PDF-test charts may show differences by up to 25 CIELAB (about 1/3 of the colour difference black-white) on a monitor and no difference on a printer and vice versa. According to user requirements with the BAM-filter method the output is identical. Additionally the output is identical if the CIELAB coordinates of Fig. 1 are used.

7. Conclusions

1. The support of the Federal Environmental Agency (Umweltbundesamt UBA) for the remanufacturing and refilling of the toner- and inkjet cartridges should remain. The support is of advantage for the European remanufacturing industry.

2. The support of the black generation for the colour image output may reduce the toner and inkjet material expenses to about 33%. The grey output reduces the expenses to 11%. Both methods have not been supported by the Federal Environmental Agency (Umweltbundesamt UBA) up to now.

3. One can assume, that most companies of the printer industry in the USA and in Japan with a world wide turnover of **7 Billion Euro for toner- and inkjet cartridges** have no interest on a reduction of the user expenses in the direction to 33% or 11%.

4. Using black generation innovative printer and software companies may use the BAM methods to reduce the costs per page und this is simple if the standardization produces simple calculation methods which gives nearly no change in colour reproduction properties.

8. Difficulties for International and CEN-Standardization

Because of the possible turnover reduction the original manufacturer industry in the USA and in Japan may try to aggravate or to prevent the standardization in this area. There is an indication of this goal by the composition of the delegates of ten European countries in the European Task Force CEN/BT/TF 165 for the remanufacturing of toner and inkjet cartridges. Many sales members of **original manufacturer companies** (for example from HP, Canon and Epson) in Europe, which seem **not** to support remanufacturing methods, have been delegated for CEN/BT/TF 165 to influence, to aggravate or to prevent the standardization of remanufactured cartridges.

A CEN-standardization is aggravated if in voting the original manufacturer industry (from USA and Japan) has the majority compared to the European remanufacturing industry. A DIN standardization was and is possible (compare DIN 33870: 2000 and DIN 33871-1:2003). These DIN standards are applied in many european countries. In the standardization group DIN NI-28 (Information Technology - Office Equipment) the original manufacturer industry, the remanufacturing industry and the technology oriented test institutes (for example BAM, LGA) are represented equally.

9. Support of “Material efficiency of colour printer output”

BAM VIII.34-initiative “Material efficiency of colour printer output”

Improvement of the **“Material efficiency” of printer output by equal costs per pages** and equivalent reproduction properties according to DIN 33870 and DIN 33871-1:

up to the **ratio 3 by remanufactured cartridges** (lower prices compared to original cartridges)

up to the **ratio 3 by black generation** instead of chromatic generation

up to the **ratio 9 by both remanufactured cartridges and black generation**

If the user requirement of “grey image output” instead of “colour image output” is realized in the printer driver:

up to the **ratio 9 by grey image output instead of colour image output**

up to the **ratio 27 by both remanufactured cartidges and grey image output**

Support on demand

for example;

1. Industrial application by support of PhD students, which are working for 50% in the industry and 50% in the BAM-working group

2. Financial support of a PhD thesis at the Technical University of Berlin (TUB)

3. Foundation of aprofessorship “Colour image reproduction” at the Technical University of Berlin (TUB)

Remark: One European software company likes to implement both the black generation method and the BAM-filter method for equivalent colorimetric coordinates in their printer drivers for the colour image output. A cooperation and support of other groups is appreciated.

Figure 1: 12 equivalent colorimetric coordinates of 8 hues and mean grey and output

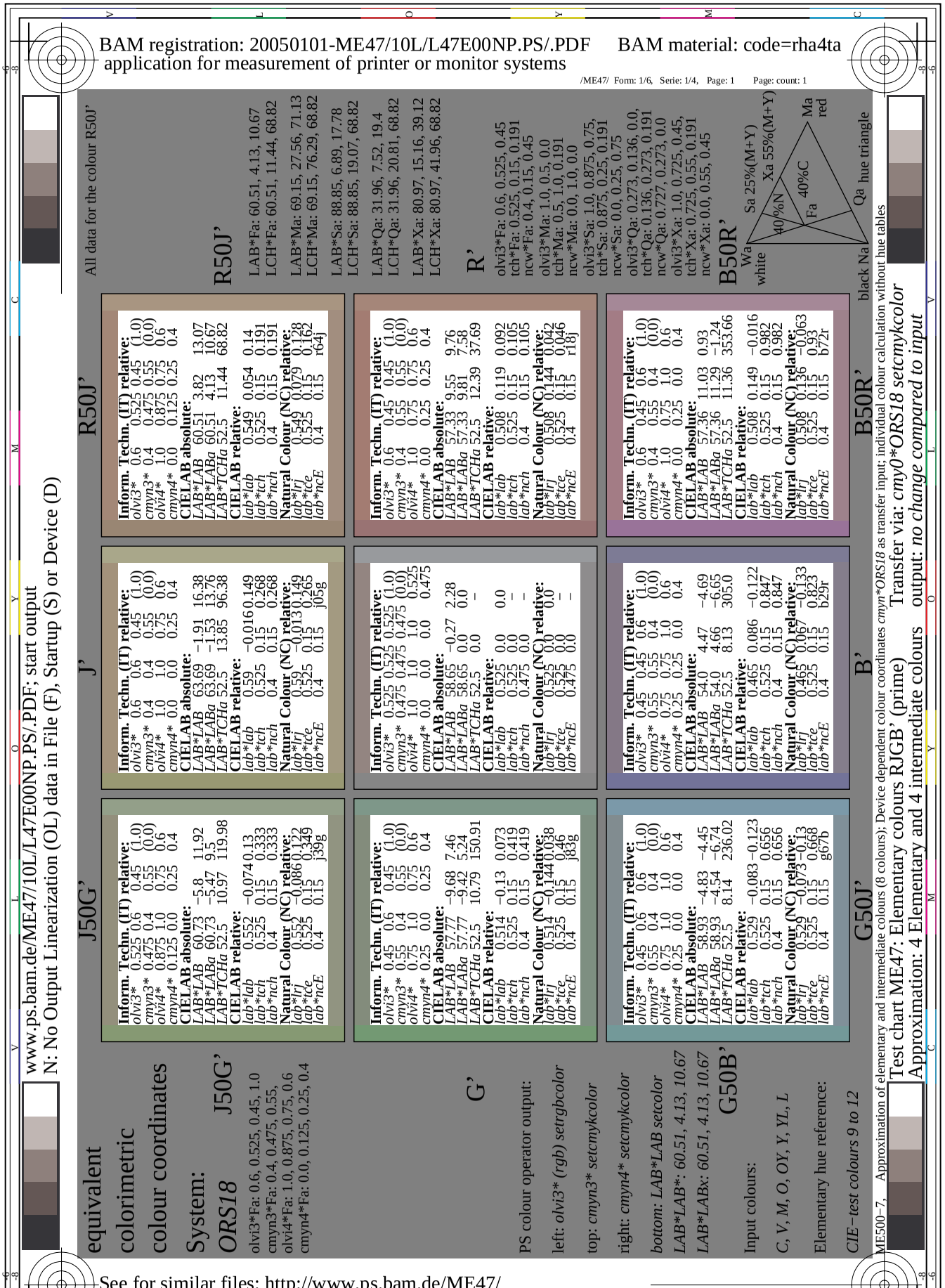

Fig. 1 shows the colours *Fa* of 8 hues which are located within in a hue colour triangle (down left in Fig. 1). The colours *Fa* may be mixed by three chromatic colours *CMY* (chromatic generation) or from two chromatic colours and black *N* (black generation), for example by 55%*(M+Y)* + 40%*C* or 25%(*M+Y)* + 40%*N*. The achromatic colour black *N* is often by a factor 3 less expensive compared to the chromatic colours *CMY*. The costs for the production of the colour *Fa* by black generation are therefore reduced for the colour *Fa* to 24% compared to chromatic generation.

Fig. 1 produces the three rectangle colours on each square edge with the first three triples of equivalent colour coordinates. In newer applications (since 2002) the three colours are by monitor output often very different, often are the first two or all three equal in a printer output.

BAM filter produce according to the user requirement for the 12 equivalent colour coordinates which are used in corresponding PS- and PDF-BAM-test charts equal output colours both by the monitor and with the printer

9. Standards, Technical Reports and References

The author was active as a leader for the standards [1] to [3] and was editor of the International documents [4] to [7].

[1] **DIN 33870:2000:** Requirements and tests for the remanufacturing of used toner modules black for electrophotographic printers, copiers and fax machines (Anforderungen und Prüfungen für die Aufbereitung von gebrauchten Tonermodulen schwarz für elektrophotographische Drucker, Kopierer und Fernkopierer)

[2] **DIN 33871-1:2003:** Requirements for remanufacturing of used inkjet heads and inkjet tanks of inkjet printers (Aufbereitung von gebrauchten Tintendruckköpfen und Tintentanks für Tintenstrahldrucker)

[3] **DIN 33866-1 bis 5:2000**: Information technology – Office machines – Machines for colour image reproduction: Method for specifying image reproduction of colour devices by digital and analog test charts, This standard includes analog DIN-test charts no. 1 to 4.

[4] **ISO/IEC DIS 19839-1 bis -4:2000**; Information technology - Office machines - Colour image reproduction equipment, Methods for specifying image reproduction of colour devices by digital and analog test charts

[5] **ISO/IEC 15775:1999**; Information technology – Office machines – Machines for colour image reproduction - Method of specifying image reproduction of colour copying machines by analog test charts – Realisation and application

[6] **ISO/IEC TR 19797:2004**, Information technology - Device output of 16-step colour scales, output linearization method (LM) and specification of the reproduction properties, ISO/IEC JTC1/SC28 (21pages). For an old public version of this document see the URL (21 pages, 280 kByte)

http://www.jbmia.or.jp/sc28/sc28docs/j28n656.zip

[7] **ISO/IEC TR 24705:2005** (under publication), Method of specifying image reproduction of colour devices by digital and analog test charts, (79 pages). For an old public version of this document see the URL (79 pages, 1.5 MByte)

http://www.jbmia.or.jp/sc28/sc28docs/j28n689.zip

[8] Richter, K. (2004), Natural colour connection space (NCCS) between input and output for office systems, International Semina on Information Office Equipment Standardization, Korean Agency for Technology and Standards, Seiten 71-92, siehe die URL (1.4 MByte, 27 pages)

http://www.ps.bam.de/BAMAG1.PDF

[9] Richter, K. (2005), Linear relationship between CIELAB and device coordinates for Colorimetric Image Technology (CIT), see the URL (140 kByte, 6 pages)

http://www.ps.bam.de/CIE05.PDF

[10] Deutsches Institut für Normung (DIN) 2004-12: The German Standardization Strategy, see

http://www.din.de

[11] Institute of Fair Trading, December 2002, Report OFT610, IT goods and services, see

http://www.oft.gov.uk/News/Publications

Remark: For further publications and analog and digital BAM-, DIN-, CEN- and ISO/IEC-test charts, see (> 1 Million connections/per year since 2002):

http://www.ps.bam.de