Test charts for yield, emission and reproduction properties of printers

both achromatic and chromatic and based on DIN 33870, 33871-1 and 33866

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Abstract

The application of the digital DIN- and ISO/IEC-test charts which are defined in the standards DIN 33870, 33871-1 and 33866-1 to 5 and in ISO/IEC 15775 is described for the test of yield, emission, and reproduction properties of achromatic and chromatic printers. The standards may serve as a basis for a European Standard Workshop Agreement for the test of yield, emission and reproduction properties of printers.

There is a need for such European Standards within one year. This aim has been recently published by a report on the European market of inkjet printers by the english Office of Fair Trading. DIN has done important steps with several standards in this field within the last years and e. g. with the publication of DIN 33871-1 for inkjet printers in 2003.

Test charts with 16 step colour series and additional test charts are proposed for the test of relative and absolute yield, emission and the colour reproduction properties of printers.

1.0 The problem of yield and emission for printers and multifunctional devices with printing components

For the test of yield and emission test charts are necessary. DIN developed test charts in DIN 33866-1 to -5 for the test of colour reproduction properties of copiers, printers, scanners and monitors. The DIN-test charts served as basis for ISO/IEC-test charts which are now used in the International Standard ISO/IEC 15775 for colour copiers. For the test of yield of achromatic and chromatic printers now similar test charts are defined in DIN 33870 and 33871-1.

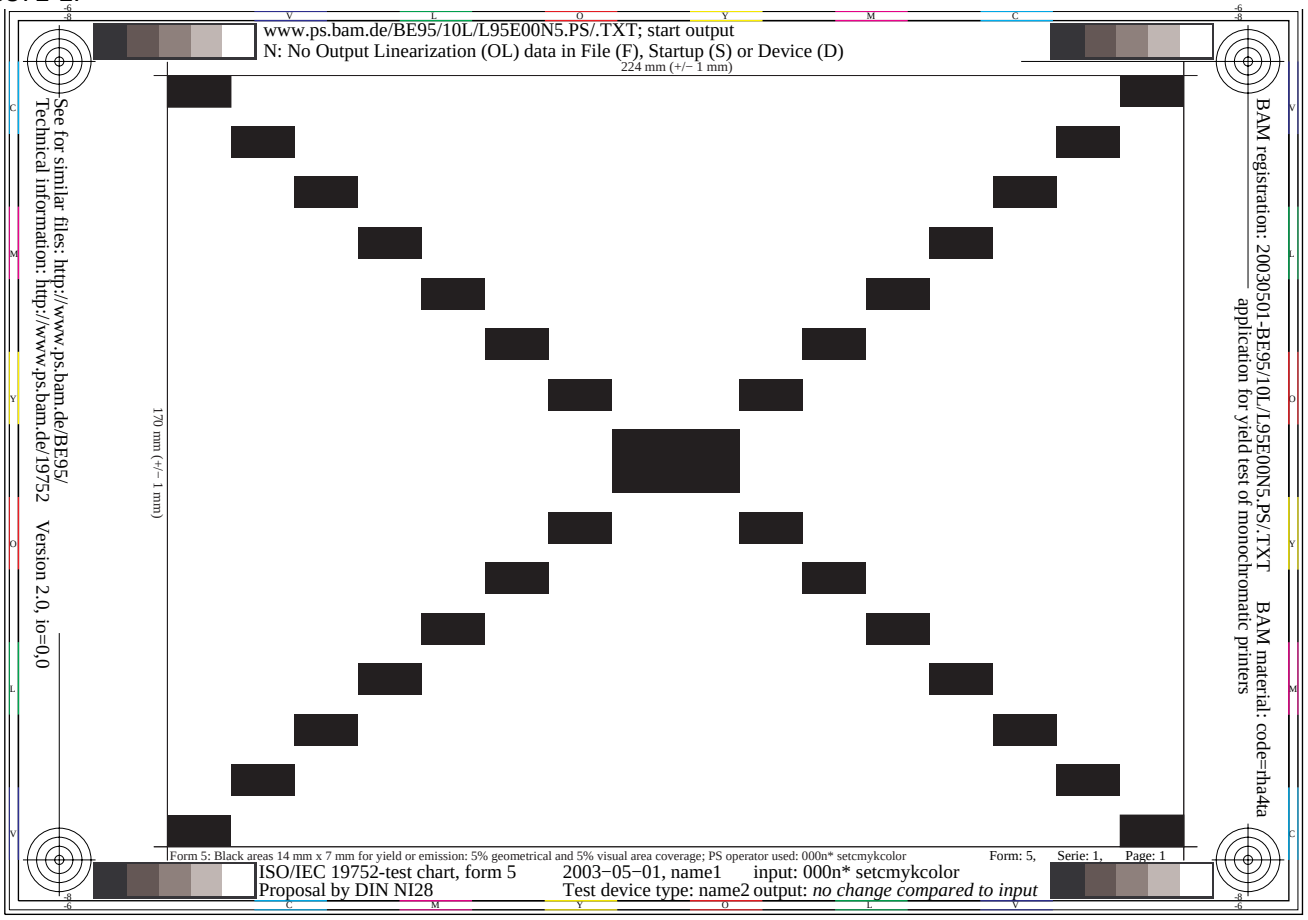


Figure 1: DIN-test chart according to DIN 33870 with black samples for the test of yield of achromatic printers

The x-chart form is used in DIN 33870 and 33871-1 and is chosen by different reasons. The printers are designed to cover not more then 5% of the page per colour in a continuous test. The black rectangle areas of Fig. 1 cover 5% of

the A4 page area. If the toner is taken from different areas of the toner bottle and similar for a vertical and horizontal (portrait and landscape) output of the A4 page, then the amount of shaking procedures is minimized.

The geometrical area coverage of Fig 1 is 5% or given by

$a_{geo,Fig\ 1}$ = 32 $a_{samples}$ / a_{A4} = 32 (14 mm x 7 mm) / (210 mm x 297,6 mm)] = 0.05

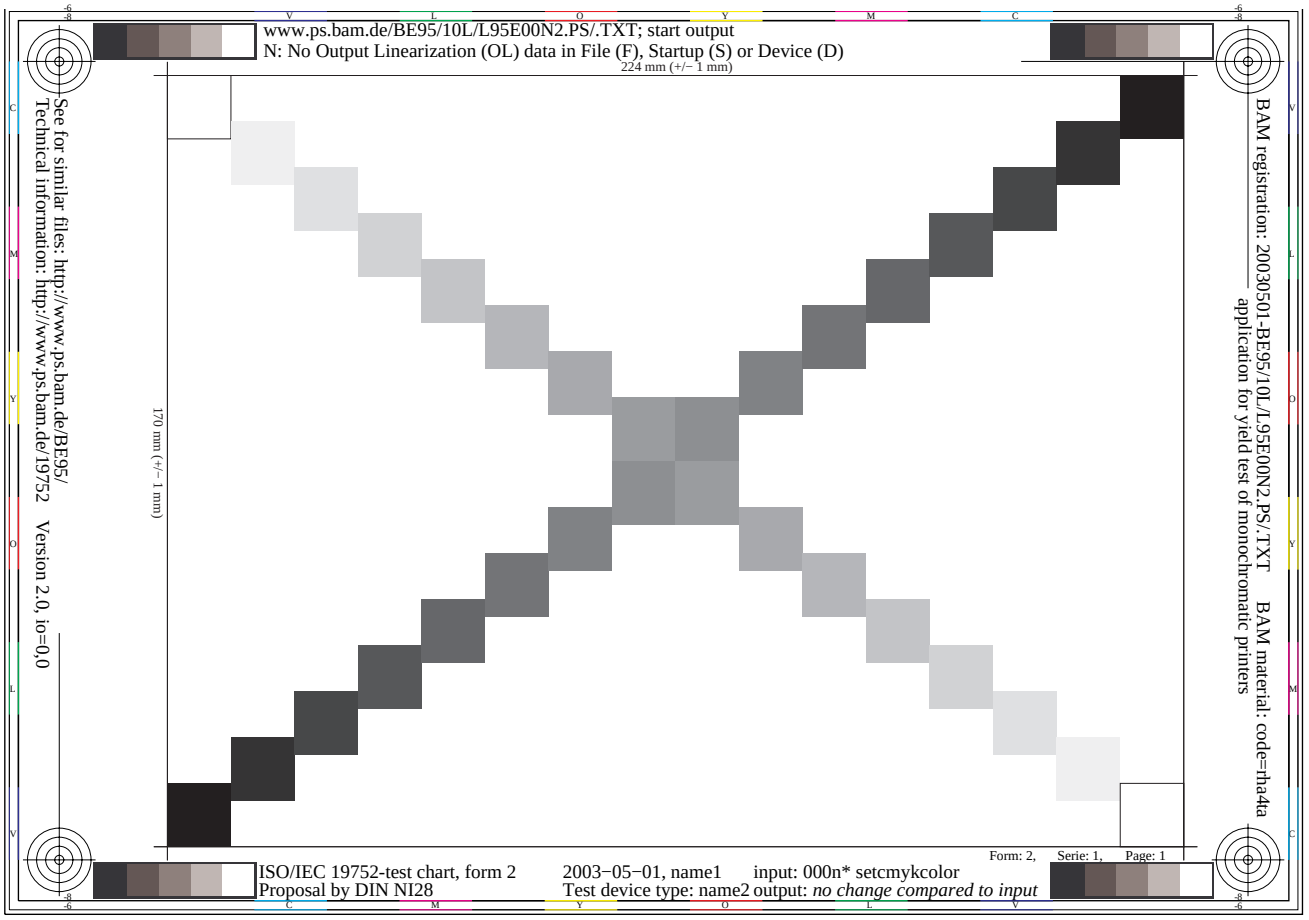


Figure 2: Test chart according to DIN 33870 with grey samples for the test of yield of achromatic printers.

The test chart of Fig. 2 (new proposal) includes 2 times 16 grey samples of twice the size compared to Fig. 1. In Fig. 2 the geometrical area coverage is 10% including the two white areas or given by

$a_{geo,Fig\ 2}$ = 32 $a_{samples}$ / a_{A4} = 32 (14 mm x 14 mm) / (210 mm x 297,6 mm)] = 0.10

According to DIN 33870 one can define a visual area coverage which is again 5%. For this the CIELAB lightness L* measurement data are transferred to the relative whiteness data

$w^* = (L^* - L^*_N) / (L^*_W - L^*_N)$

The letters W and N are used for White (W) and Black (N = french noir). If the output of the grey samples is equally spaced in relative whiteness w* then the visual area coverage is again 5% or given by

$a_{vis,\ Fig.\ 2}$ = 0.5 * 32 $a_{samples}$ / a_{A4} = 0.5 [32 (14 mm x 14 mm) / (210 mm x 297,6 mm)] = 0.05

The factor 0.5 in front is based on the sum of the *w** values: 1 + 0.933 + 0.877 +0.800 + ... + 0.067 + 0.00 = 0.5.

The use of the grey samples is essential for the determination of the colour reproduction properties. The printer system which includes the file format, software, colour workflow, printer driver and the printer device properties often produce too dark greys. For a mean grey with the value *w**=0.5 in the file (for black and white the values *w** are 0.0 and 1.0) often a grey is produced which is located at 25% (or in a rare case at 75%) instead of 50% on the *w** measurement scale. Then the Landolt-rings in the dark area are not seen in the next Fig. 3.

Remark: The near black Landolt-rings consist of a combination of black and the first dark grey step no. 00 and 01. In the printing area these steps are called F and E in hex code.

DIN 33866-1 to -5 requires a linear output spacing in relative CIELAB for the DIN-test charts which are linearly spaced between 0.0 and 1.0 in the file. DIN 33870 uses output linearization for the yield test.Then all the Landolt-rings are recognized. The Draft Technical Report ISO/IEC DTR 19797:2004 describes a method for output linearization of printers. Recently new Asian ISO/IEC-test charts according to ISO/IEC 15775 Amendment:2004 have been produced. The achromatic one no. 3 is shown in the next Fig. 3.

2.0 Availability of the DIN- and ISO/IEC-test charts

All the digital DIN- and ISO/IEC-test charts are freely available on the server

http://www.ps.bam.de

in different file formats, e. g. *PostScript* (PS), *Portable Document Format* (PDF) and *Corel Draw* (CDR).

Fig. 1 to 3 show examples for the black and white case. For the yield test, e. g. 2500 pages of Fig. 2 are printed without the frame area. Any output includes as text only a form, a series and a page number at the right bottom to record the test material within the continuous test. Details are listed in the workflow charts of the standards.

3.0 Image reproduction properties are tested within the yield test procedure

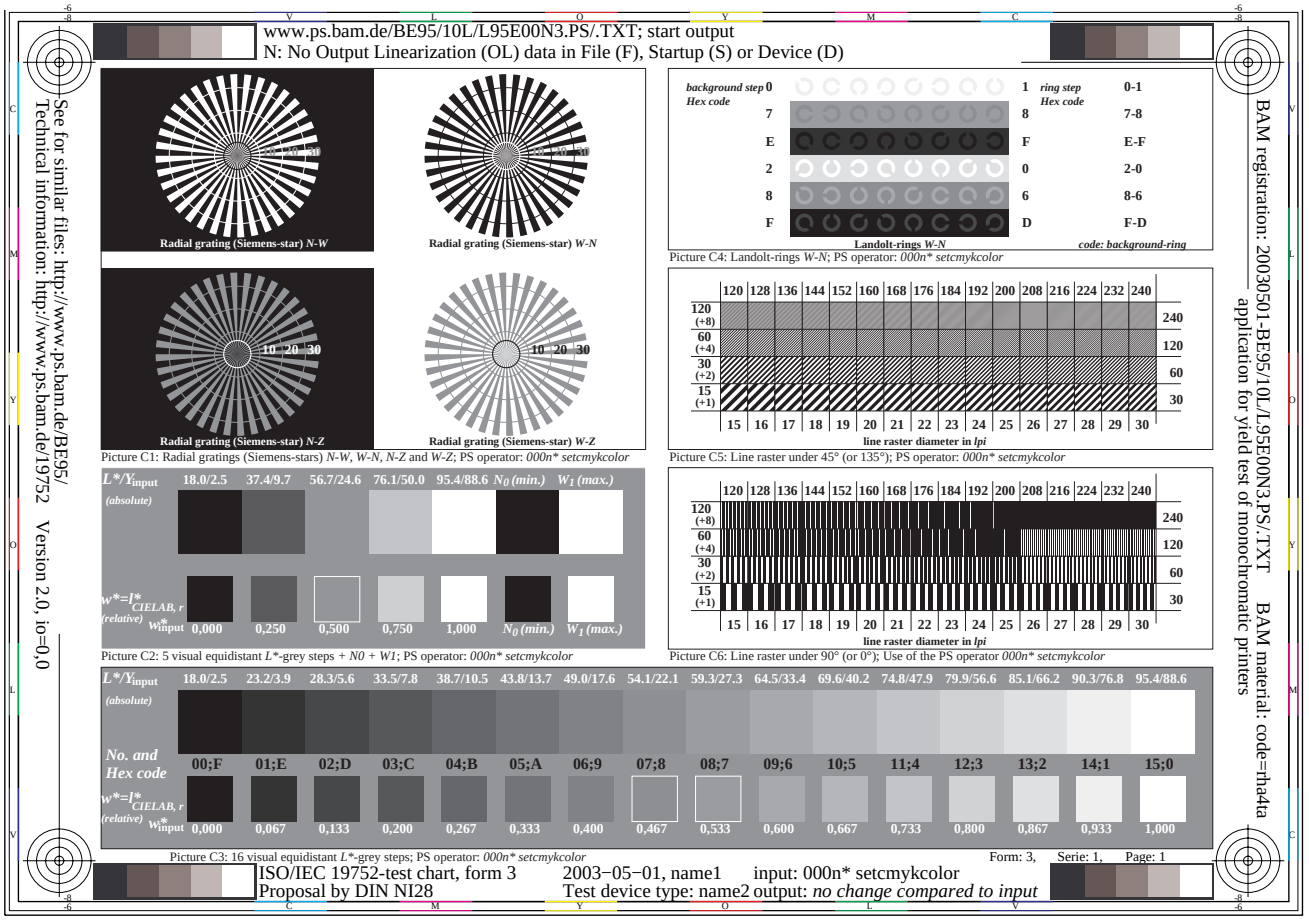


Figure 3: ISO/IEC-test chart according to ISO/IEC 15775 for the test of colour reproduction properties of black and white and colour copiers

The above ISO/IEC-test chart according to ISO/IEC 15775:1999 is defined for the application of copiers.

Input	Output	Input and output media and applications			Standard
		Input media	Output media	Application	
-	-	-	-	**Basis**	**DIN 33866-1**
analog	**analog**	DIN-test chart (hardcopy)	Hardcopy	**Copier**	**DIN 33866-2**
analog	**digital**	DIN-test chart (hardcopy)	File	**Scanner**	**DIN 33866-4**
digital	**analog**	DIN-test chart (file)	Hardcopy Softcopy	**Printer** **Monitor**	**DIN 33866-3** **DIN 33866-5**

INFDE000:DETNKDE.PS

Figure 4: Relationship of the standards DIN 33866-1 to -4 for the applications copiers, scanners, printers and monitors.

For copiers a so called analog test chart (an original) is copied and this is defined as analog – analog workflow. The

same test chart is defined and used for the digital – analog and the analog – digital workflow according to DIN 33866-1 to 5.

4.0 Example of a combined yield and colour reproduction property test

DIN 33870:2001 is under revision now. The improved standard includes the yield test and many image reproduction property tests within one file. Testing time is reduced and resources are reduced as the pages (e. g. 7 in the improved DIN 33870) for the test of image reproduction properties and its change are now printed continuously only once in each series. No extra tests for image reproduction properties are necessary. An example file is at the URL

http//www.ps.bam.de/BE95/index.htlm

The text page of this example is based on a layout proposed for ISO/IEC/FCD 19752:2003. The example text page taken from ISO/IEC/FCD 19752:2003 includes two additional pictures to simulate the more modern web applications with more graphics. Each complete output consists of e. g. 10 series with 250 pages. The example file produces 20 pages. The whole output includes the start page no. 1 (with the above text and graphics) and 2 pages (instead of 242 pages in the final test) with the 16 step grey x-chart of Fig. 2 and seven different image reproduction pages no. 4 to 10 (instead of pages no. 244 to 250 in the final test). One page of the seven image reproduction pages is reproduced in Fig. 3.

5.0 Recent DIN-test charts for inkjet printers according to DIN 33871-1:2003

The latest standard DIN 33871-1:2003 specifies the relative yield of refilled compared to the OEM cartridge for inkjet printers.

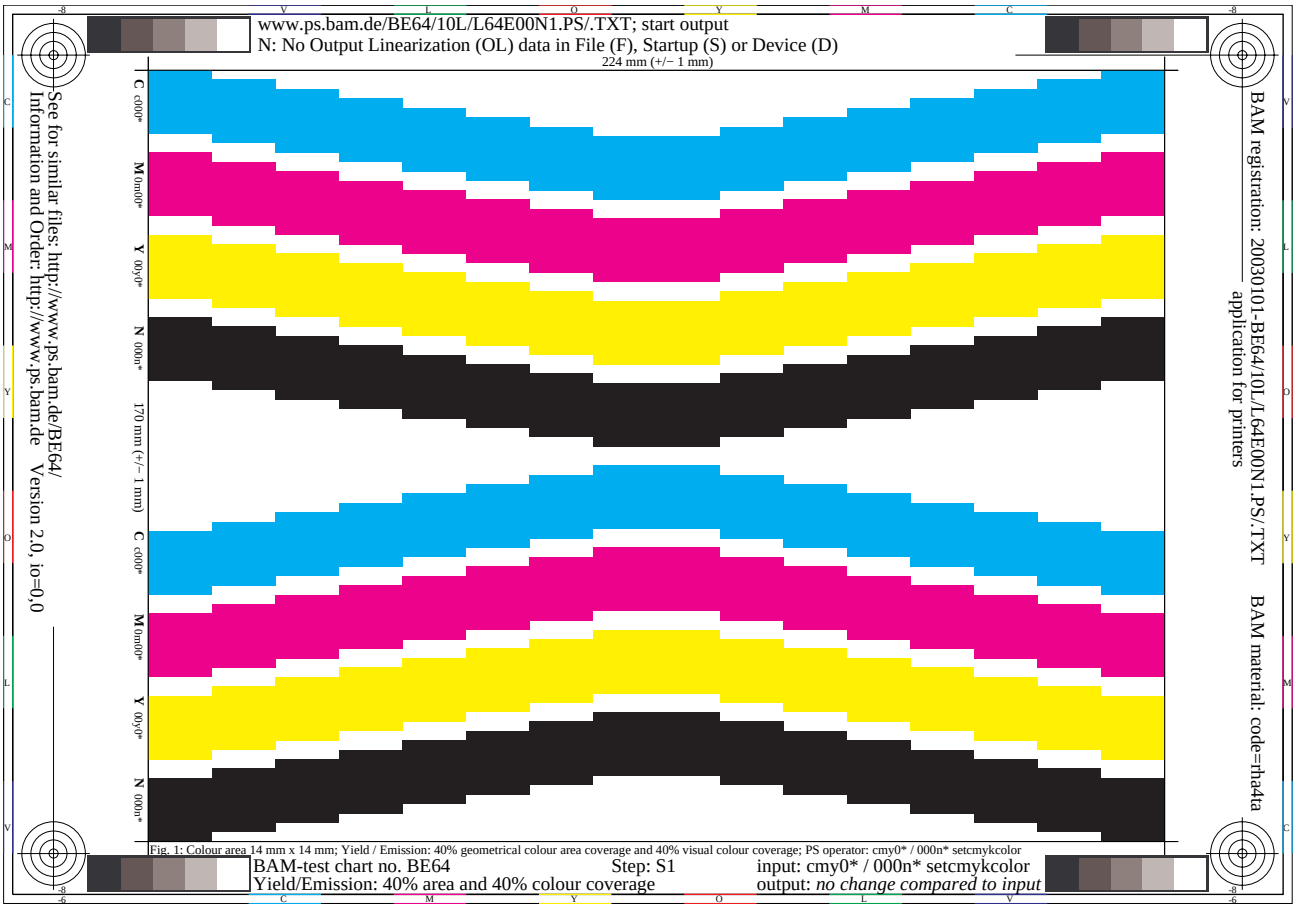


Fig. 1: Colour area 14 mm x 14 mm; Yield / Emission: 40% geometrical colour area coverage and 40% visual colour coverage; PS operator: cmy0* / 000n* setcmykcolor

Figure 5: DIN-test chart for the relative yield test of the refilled compared to the OEM cartridge for colour inkjet printers

DIN 33871-1 uses 40% geometrical and 40% visual coverage for the relative yield test of inkjet printers. This is twice the amount allowed in a continuous test for colour laser printers. There is no restriction about the amount of colour per page for inkjet printers. For a continuous test of colour laser printers the coverage must be reduced from 40% to 20% (for each colour not more then 5%).

6.0 Proposed test charts for the emission test of printers with up to six colorants

The x-chart of Fig. 2 has already been used in research projects supported by the German Environmental Institute to measure the emission of achromatic laser printers. New projects are planed to measure the emission of colour inkjet and colour laser printers. The printers on the market use normally three chromatic colorants (yellow, magentared and cyanblue) and the achromatic colorant black. Additionally there are printers on the market which use five colorants including a light magentared and a light cyanblue.

These two colorants are not used by the print of Fig. 5. For the measurement of the emission of all 5 colorants one has to print near whitish colors which use these two additional colorants for printing. Therefore for the emission test of the 5 chromatic colorants it is necessary to print the 16 step series between White W and CMY.

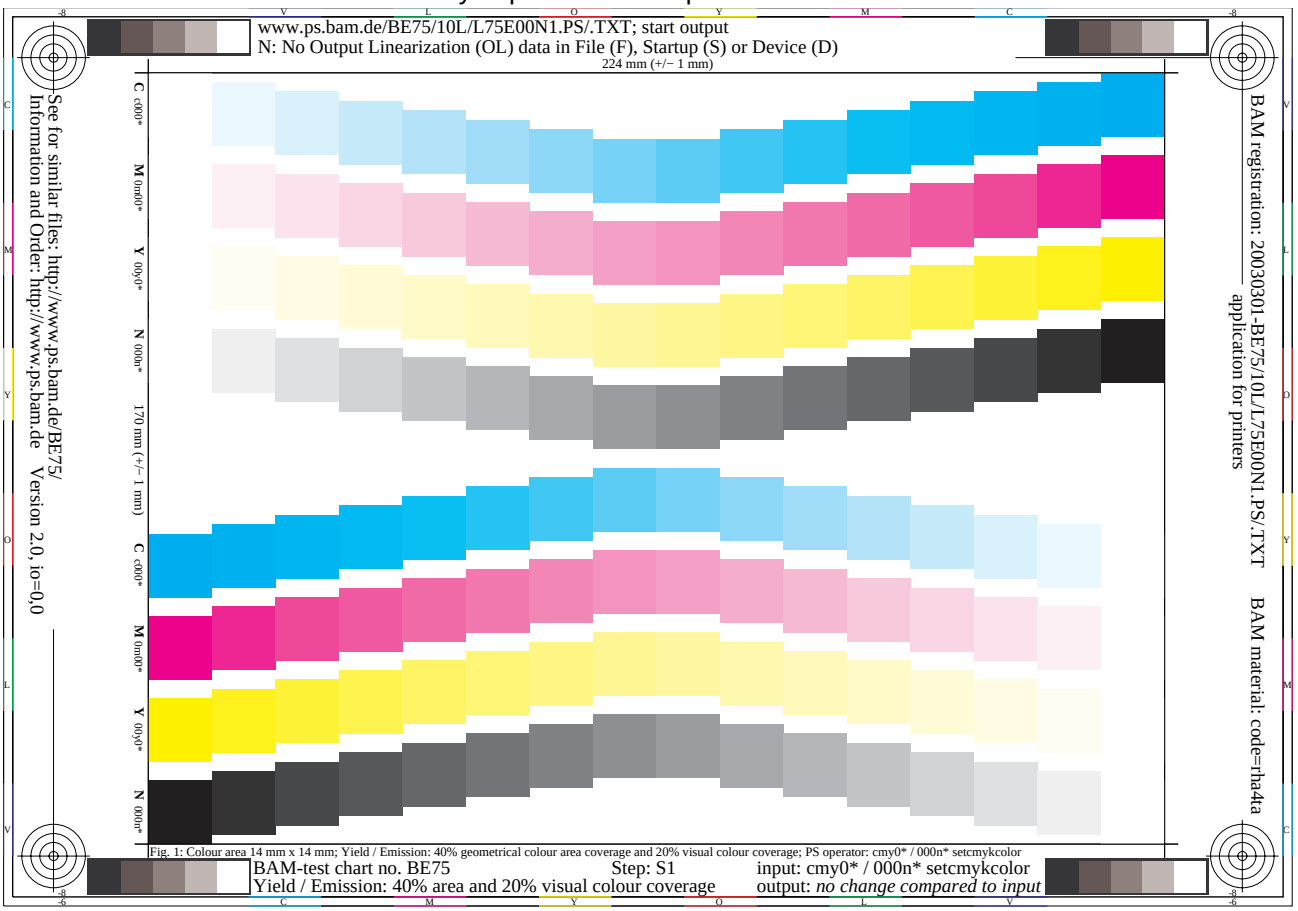


Figure 6: Proposed DIN-test chart for the test of emission of colour inkjet and colour laser printers

For the emission test one can use 40% geometrical and 20% visual coverage. This amounts are allowed for both colour laser and inkjet printers in a continuous test and shown in Fig. 6. The print of Fig. 6 will use the light Cyanblue and light Magentared colorants to produce the whitish steps. So only this test chart (and not the test chart of Fig. 5) can test the emission of the 5 chromatic colorants.

7.0 Appropriate test charts with 16 step grey and colour series for all application

The test charts of Fig. 2 and 6 (16 step grey scale and 16 step colour scales) are necessary for the measurement and the linearization of the output. Without output linearization the test results for image reproduction properties are not repeatable (variation of a factor 2) and therefore a test without linearization seems unacceptable for a DIN- or European Standard.

In the case of the **relative yield** test with only the comparison between the refilled and the OEM module the influence of the linearization on the reproduction properties is reduced. But for the two tests **absolute yield and emission** the output linearization is required. The additional time for output linearization seems to be less than 10% of the whole time needed for the test according to the experience of many companies which work for and with DIN 33870. Therefore it is appropriate to use output linearization in all cases. There is the advantage that some test results of relative and absolute yield can be compared and must not be produced again. One must realize that a standard absolute yield test produces at least an output of 22.500 pages (for 3 printers and 3 cartridges).

For the **relative yield** test an OEM cartridge serves as **reference**. As long as this OEM cartridge is stable then the test procedure for reference materials can be applied. Only one (or up to three) tests seem to be sufficient to define the **relative yield.** The test of 3 cartridges is required in the DIN standard.

For the **absolute yield** test it is proposed to use at least three printers and three cartridges (9 cases). Then with the statistical methods the amount of printed pages can be calculated for the **absolute yield**.

But there are other problems with the text to be printed in the achromatic and chromatic case. The achromatic text page of ISO/IEC/FCD 19792 seems not to be appropriate because the text may be printed thin or thick which may change the yield by a factor 2. There is no international standard how to print the text. Therefore it seems that only the 16 step x-charts fulfil the requirement of an appropriate reference. The **16 step reference scales** of the DIN-standards which are produced by output linearization **are a standard basis** for both the test of **yield and emission**

of both the **achromatic and chromatic printers**.

8.0 ISO/IEC International Standards and the decision for ISO/IEC-Technical Reports for image reproduction

DIN proposed in 2001 in DIS ISO/IEC 19839-1 to 4 to use the ISO/IEC-test charts which are defined for copiers also for printers in an International Standard. But an ISO/IEC Ballot Resolution Meeting could not agree on DIS ISO/IEC 19839-1 to -4 as an International Standard and agreed instead on an ISO/IEC Technical Report.

After the acceptance of a new work item in 2003 on the topics there has been an unanimous decision at the ISO/IEC SC28 Plenary meeting to vote now internationally on the Proposed Draft Technical Report ISO/IEC 24705. This international vote is expected in 2004

Some opposition may occur because less toner and ink is needed if the user requirement is fulfilled to produce an optimal recognition of e.g. the Landolt-rings on printers. Additionally the output of different devices will become much more similar which is an additional essential requirement of the users. But if this user requirement is fulfilled then this reduces e. g. the difference of high and low cost printer devices. So some companies which produce high cost devices may not be interested on International Standards on a colorimetric basis in this field which make the output of many devices much more similar.

9.0 Special importance of European Standards for the European Market

The European Community needs Standards in the field of yield, emission and reproduction properties. An International ISO/IEC-Technical Report (if accepted) in this essential field of Image Technology seems not sufficient. This situation is identified e. g. in a report of the Office of Fair Trading (2002), see references

The **user requirement** for **optimal recognition** includes also an **essential safety aspect**. For instance a crack or any other failure of a material component may not be detected because of inadequate image reproduction at a working place, e. g. by the standard visual inspection in the field of non destructive testing. Up to now there is no International Standard which defines how to reproduce the digital values *w** in the file on a printer. Many hard and software companies have its own standards and procedures. The DIN standards fulfil this gap. The international opposition to have International Standards in this fields and the International decision to produce (probably) Technical Reports seems not acceptable within the European Community. Therefore the DIN standards are now proposed by DIN NI28 (after several years of international work and mainly US opposition) to form the basis for European Standards at an European Standard Workshop Agreement in 2004.

The proposed **European Standards for yield, emission and image reproduction** avoid many **electronic garbage** and supports the European toner and ink industry. The recent report of the english Office of Fair Trading which is supported by the government **requests standards for the yield test** of printer cartridges until **end of 2003**. Because of the lack of a standard there is no possibility for a consumer or the testing institutes to compare the cost per printed page.

In the market the cost of a new printer including a cartridge (sometime only half filled) is often similar as the cost of the new cartridge. This price politics of the companies produces **a lot of electronic garbage** because the consumer tends to throw away the old printer and to buy a new printer instead of a new cartridge. If on the other side the printer is used for a long time then the normal consumer have to spent often up to 17 times the money for the cartridges compared to the printer price (according to the Fair Trade report). Therefore the cartridge price seem to be much to high compared to the printer price and in fact the refilling toner and ink industry often offers refilled cartridges for much less then half of the Original Manufacturer (OEM) price. DIN has saved according to a press announcement about 35.000 EURO in 2000 by using refilled instead of OEM toner modules.

10. Support of the European Refilling Industry for the European Standard Workshop Agreement

The **European refilling industry** is highly interested to produce **European Standards** which allow to specify the yield and the cost per page. Health aspects, e.g. the test of the used colorants are included in the DIN standards. Other health aspects, for example the test of **emission** of toner and ink by the printers are on the way. The support of the European Refilling Industry for the Standards DIN 33870 and 33871-1 for achromatic and chromatic printers has produced some conflicting interests. Finally the three groups “Refilling Industry”, “OEM Industry” and “Testing Institution” agreed e.g. in 2003 to publish DIN 33871-1 for the yield test of inkjet printers.

The present standards DIN 33870 and 33871-1 define the **relative yield** of the refilled cartridge compared to the OEM cartridge. So at least **one OEM module** must be used for this comparison test if the OEM Module is stable. The DIN standard procedure requires three OEM modules. The refilling industry has included **image reproduction property tests**. e. g. with the test chart of Fig. 3 and others.The tests according to DIN standards specify the same or very similar image reproduction properties of the refilled compared to the OEM cartridges.

11.0 The influence and problem of the colour workflow of the digital test charts on the output

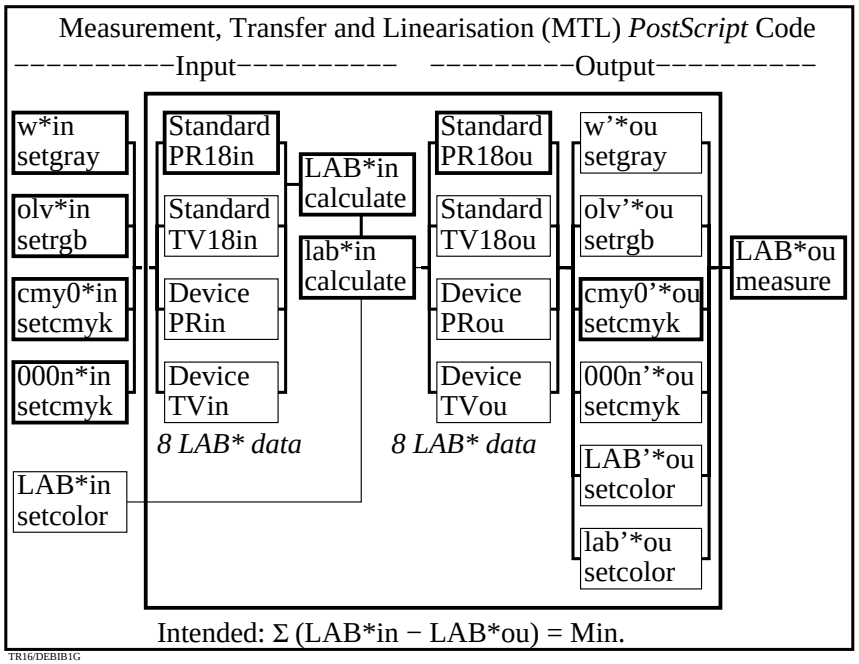
The colours in the digital test charts are defined by corresponding colour coordinates in different colour spaces, for example the 5 grey steps in *LAB** (CIELAB), *w** (in DeviceGrey), *000n** (CMYK), *cmy0** (CMYK), and in *olv** (RGB).

5 steps of grey series black - white (N - W)	**Colour space, colour space coordinates and PostScript operator calculations according to ISO/IEC 15775:1999-12**														
Linear mixture between black and white in CIELAB colour space	**CIELAB** ***LAB* (absolute)*** ***LAB* setcolor***			***l** CIE* ***w* = l** setgray*	**CMYN (CMYK)** ***000n** setcmykcolor*				**CMYN (CMYK)** ***cmy0** setcmykcolor*				**OLV (RGB)** ***www** setrgbcolor*		
1,00 N + 0,00 W (black N)	18.01	0.50	-0.46	0,00	0,00	0,00	0,00	1,00	1,00	1,00	1,00	0,00	0,00	0,00	0,00
0,75 N + 0,25 W	37.36	0.13	0.84	0,25	0,00	0,00	0,00	0,75	0,75	0,75	0,75	0,00	0,25	0,25	0,25
0,50 N + 0,50 W	56.71	-0.24	2.15	0,50	0,00	0,00	0,00	0,50	0,50	0,50	0,50	0,00	0,50	0,50	0,50
0,25 N + 0,75 W	76.06	-0.61	3.45	0,75	0,00	0,00	0,00	0,25	0,25	0,25	0,25	0,00	0,75	0,75	0,75
0,00 N + 1,00 W (white W)	95.41	-0.98	4.76	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,00	1,00	1,00

TR16/DESERCW2.PS

Figure 7: Corresponding color coordinates in five different device colour spaces including CIELAB for standard offset colours, compare ISO/IEC 15775.

The output of the colours is **equal** with some software on some devices if the corresponding colour coordinates are used in the files but usually up to four different colours are produced for the corresponding colour coordinates. One software which is to a high degree in agreement with colorimetry and which produces the same output for the DIN- and ISO/IEC-test charts in PostScript (and usually also PDF) is the free available software *GhostScript* which is available for Windows, Mac and Unix.



TR16/DEBIB1G

Figure 8: Transformation of device input colour coordinates to CIELAB and to device output colour coordinates in different device space

The output is the same for the corresponding input colour coordinates defined in the five input device spaces of Fig. 8 (left) which is a basic user and a colorimetric requirement.

A solution of most of the problems is a separate colour software which is programmed in PostScript. This colour software is called MTL code (Measurement, Transfer and Linearization). The software takes the colour coordinate of the above corresponding color coordinates of the above five device colour spaces and produces the device independent CIELAB data which are shown in Fig. 8. Then these data are equal for corresponding colour coordinates and the output is equal

Remark 1: The default values of the software *Adobe Acrobat, Illustrator and Photoshop* produce different output colours on the monitors. Former versions, e.g. *Adobe Photoshop 3.5 on Unix* produce the same colours. On many PostScript printers the PDF output is equal on the printer and the monitor output is different. This is very confusing for the users. For many applications and for the transformation to other file formats such as GIF, TIF, JPG it seems essential to change the default settings of the software for the monitor output.

One may test the output in the office on printers and monitors by the achromatic and chromatic output of the files

http://www.ps.bam.de/DE81/10L/L81E00NP.PDF

http://www.ps.bam.de/DE84/10L/L84E00NP.PDF

The use of the MTL code (in FP files instead of the NP files) produces the same output for corresponding colour data

http://www.ps.bam.de/DE81/10L/L81E00FP.PDF

http://www.ps.bam.de/DE84/10L/L84E00FP.PDF

12.0 Summary

A European Standard Workshop Agreement (ESWA) is proposed in 2004 to produce European Standards for the test of yield, of emission and of reproduction properties of achromatic and chromatic printers.

The essential part is the agreement on test charts and on test methods. Test charts with 16 step grey and colour scales serve as reference for all applications. There are several acceptable proposals using the DIN-test charts of DIN 33870, 33871-1 and DIN 33866-1 to -5. The test charts of DIN 33866-1 to -5 are identical to the test charts of ISO/IEC 15775 and ISO/IEC PDTR 24705:2004. A text page proposed in ISO/IEC FDIS 19752:2004 may be used in a modified version as one of the additional test pages for the test of reproduction properties.

Standard methods for the tests are already described in the standards. Therefore the DIN- and ISO/IEC-standards form a good basis for a European Standard Workshop Agreement. Up to now there is no International Standard in the area. The DIN standards have produced conflicts e. g. with the US printer companies which seem to have no or very less interest for International Standards in this field on a colorimetric basis.

There is a need for such European Standards within one year. This aim has been recently published by the english Office of Fair Trading within a report for the market of inkjet printers. This Report is available in Internet. DIN has done important steps with several new standards in this field, recently with the publication of DIN 33871-1 for inkjet printers in 2003.

13.0 References:

ISO/IEC 15775:1999-12: Information Technology - Office machines - Method of specifying image reproduction of colour copying machines by analog test charts - Realisation and Application, 50 pages

DIN 33866-1 to -5, edition:2000-07 – Information technology - Office machines - Colour image reproduction equipment - Part 1: Method for specifying image reproduction of colour devices by digital and analog test charts, Classification and principles. This standard includes four analog DIN-test charts no. 1 to 4 equally spaced in CIELAB for copiers, printers, scanners and monitor

DIN 33870, edition:2001-01 – Information technology - Office machines - Requirements and tests for the preparation of refilled toner modules for electrophotographic printers, copiers and facsimile machines

DIN 33871-1, edition:2003-10 – Information technology - Office machines - Preparation of refilled inkjet print heads and inkjet tanks for inkjet printers

For the **digital test charts** of the national and International Standards DIN 33866-1 to -5, DIN 33870, DIN 33871-1, ISO/IEC 15775, DIS ISO/IEC 19839-1 to 4, ISO/IEC FDIS 19752, ISO/IEC PDTR 24705, and ISO/IEC DTR 19797 see for example

http://www.ps.bam.de/33871E

ISO/IEC DTR 19797:2004, Draft Technical Report, Type 3: 2004-01 (ISO/IEC SC28) – Information technology – Office machines – Machines for colour image reproduction – Device output of 16 step colour scales, output linearization method (LM) and specification of the reproduction properties, see (1.200 kByte, 22 pages)

http://www.ps.bam.de/19797E

Proposal for digital ISO/IEC-test charts for yield according to ISO/IEC FDIS 19752:2004: Method for the determination of toner cartridge yield for monochromatic electrophotographic printers and multifunctional devices that may contain printer components, see

http://www.ps.bam.de/19752E

K. Richter, Analog and digital ISO/IEC-colour charts for different reproduction tests and for the efficient use of colour in design, (1000 kByte, 6 pages), AIC meeting, Maribor/Slowenia, 2002, see

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

Office of Fair Trading, Consumer IT goods and services, see e. g. sections “Printers and inks” and “Examples of ink cartridge price comparison”, Dec. 2002, 95 pages, see Consumer IT goods and services, No. OFT610, 336 kbyte in PDF

http://www.oft.gov.uk/News/Publications/Leaflet+Ordering.htm

For further information see e. g. the section publications by the URL
http://www.ps.bam.de