Images in ISO/IEC-test charts which show basic problems of colour reproduction and produce equal output for corresponding colours defined in CIELAB related device spaces

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Abstract

Corresponding colours of the *olv** and *cmy0** colour spaces (described by the **PS image operators** "4 colorimage, 3 colorimage and image" and described by the **PS vector graphic operators** "setcmykcolor, setrgbcolor and setgray") show in a lot of cases an **equal** output as required by users and colorimetry. For many software – hardware combinations the colours defined in the *olv** and *cmy0** colour spaces appear **very different** (about 15 CIELAB) in the output. An example is the software *Adobe Reader* which produces a **brownish output** on the monitor for the greys defined in the *cmy0** colour space compared to the **achromatic output** for greys defined in the *olv** colour space.

An ISO/IEC-test chart file uses the 6 different PS operators on one page. This test chart is used for a system test (combinations of hardware and software) of the device colour output. For this test the 16 step colour scales of Fig. B4 and D4 of the ISO/IEC-test chart according to ISO/IEC 15775 are used. If unexpected result occur then there are methods to correct the output. e. g. by the MTL code (Measurement, Transfer and Linearisation).

A local, global or external transfer is used to make the output of raw scan *olv*'* image data of slide and negative film very similar. A large variation of exposure has no influence on the output. For slide film this exposure range is between about -0,5 stops (under exposure) and +1,0 stops (over exposure). For negative film the exposure range is between about -1,0 stops (under exposure) and +3,0 stops (over exposure). The output appears the same for a local and external transfer. All the different exposures of two film materials are shown on one page. The global transfer is applied to an image of the flower motif (Fig. B1 and D1 of ISO/IEC-test chart according to ISO/IEC 15775).

1. Image output of corresponding 16 step greys of ISO/IEC-test charts

1.1 olv*' and cmy0*' image output of PS and PDF files on monitors and printers

This paper uses image files with hexadecimal image data. The image (pixel) data are included in PS files and for the image output the PS operators image (for w*), 3 colorimage (for olv*) and 4 colorimage (for cmy0*) are used. In many cases three transfer functions (tone functions between 0 and 1) are necessary to correct an unexpected output. Many unexpected result are produced by the image files of this paper and methods to correct the unexpected output are given. The figures used are defined in ISO/IEC 19775 [3], see also the standards [1, 2] for comparison.

For example the data *olv** = (0.5, 0.5, 0.5) which are included in an *olv** image produce in many cases a very different mean grey output compared to the data *cmy0** = (0.5, 0.5, 0.5, 0.0) which are included in an *cmy0** image (compare Fig. 1 and 3).

For example if the PS files of Fig. 1 and 3 (*olv** and *cmy0** images) are transferred to the PDF files by the software *Adobe Distiller* then usually **different** greys (about 15 CIELAB) are produced on a monitor for the corresponding *olv** and *cmy0** images.

For example other software, e. g. Mac OS Preview, produce **equal** greys on the monitor for the same PDF files with the *olv** and *cmy0** images.

For example for all known Display PostScript Systems, e. g. the application Yap on MAC OS X Server, the PS files produce the intended **equal** colours on the monitor.

The MTL code (MTL = Measurement, Transfer and Linearisation) is one method to correct the unexpected monitor output of the corresponding greys in *olv** and *cmy0** images. Not the whole MTL code is necessary and only a special inverse tone function for both the greys in images and the grey samples defined by vector graphics is sufficient. This code can be used for a local transfer of the hexadecimal image data in the file or for a global transfer of the file image data. This code can be also used for the hexadecimal image data transfer by an external program.

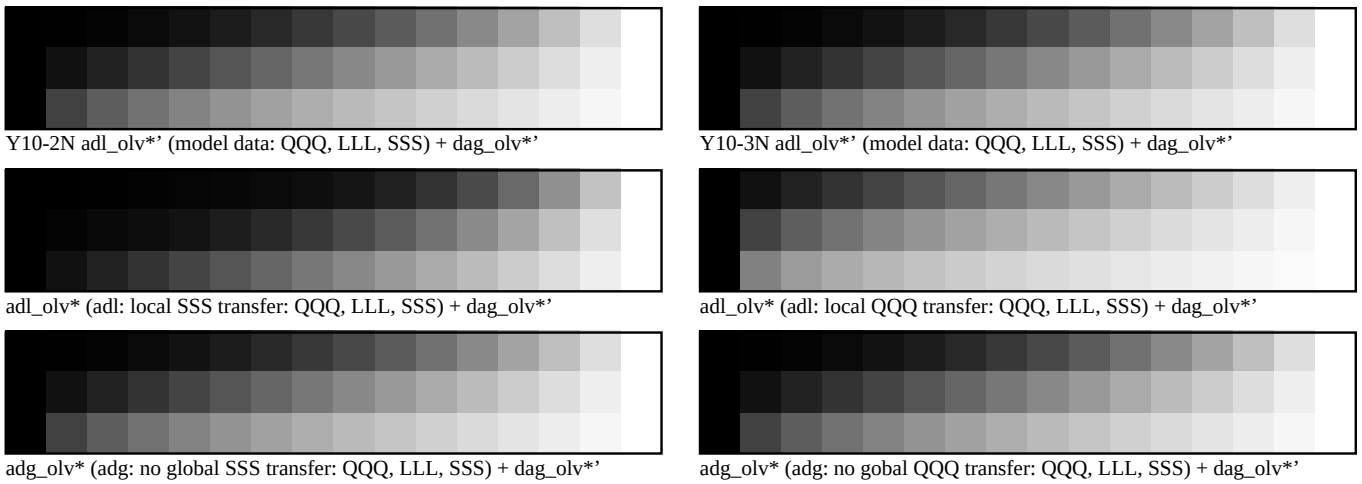

Figure 1: Three *olv 16 step gray scales; Linear (L), Quadratic (Q) and Square root (S) and modifications**

The left Fig. 1 shows in the upper part three 16 step gray scales; Linear (L), Quadratic (Q) and Square root (S). In the middle part the three grey scales are transferred by a **local** three channel Square root function (SSS) within the file. The lighter grey scale S of this part is transferred to the standard L scale and the standard L scale is transferred to the Q scale. See the files (Note: 3.PDF and 4.PDF has been produced from PS file with *Adobe Distiller versions 3.0 and 4.0)* at

http://www.ps.bam.de/DE36/10L/Y10-2X3.PS

http://www.ps.bam.de/DE36/10L/Y10-2X3.PDF

http://www.ps.bam.de/DE36/10L/Y10-2X4.PDF

The right Fig. 1 shows in the middle part the three grey scales which are transferred by a **local** three channel Quadratic function (QQQ) within the file. The darker grey scale Q of this part is transferred to the standard L scale and the standard L scale is transferred to the S scale. See the files at:

http://www.ps.bam.de/DE36/10L/Y10-3X3.PS

http://www.ps.bam.de/DE36/10L/Y10-3X3.PDF

http://www.ps.bam.de/DE36/10L/Y10-3X4.PDF

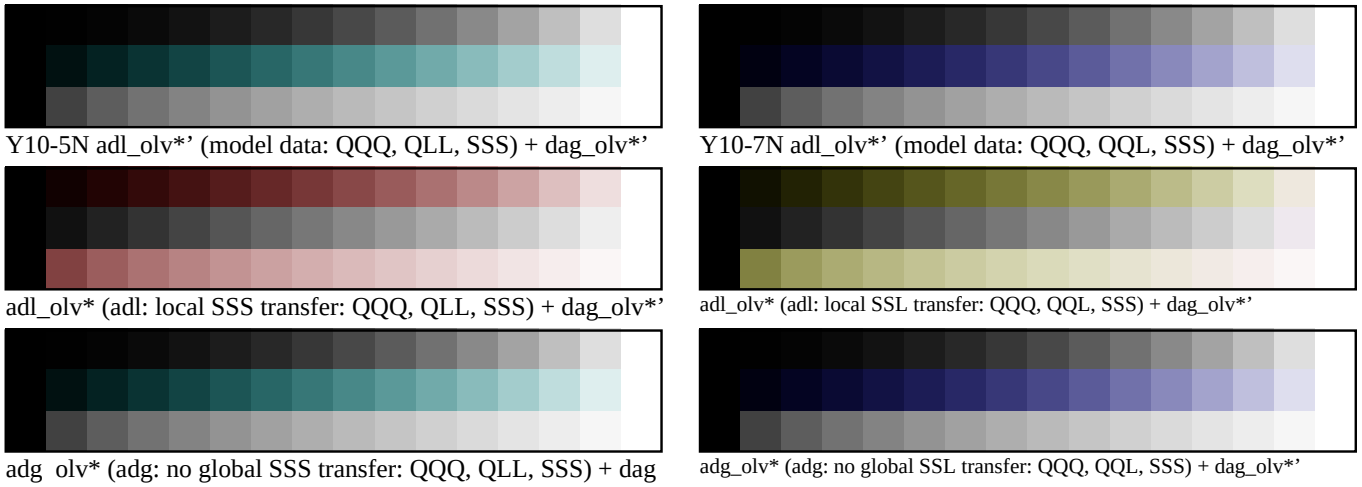

Figure 2: Three *olv 16 step gray scales and transfer by one chromatic function to achromatic colours.**

In Fig. 2 the red channel has a Quadratic (Q) red output tone function which produces a cyan blue gray scale L (upper and lower part of the left Fig. 2). In the middle part of the left Fig. 1 an inverse transfer is used to transfer back to the achromatic grey scale. This transfer is done by a **local** three channel Square root function (SSS) which transfers the cyan blue grey scale to an achromatic grey scale and the achromatic scales S and Q to reddish scales.

http://www.ps.bam.de/DE36/10L/Y10-5X3.PS

http://www.ps.bam.de/DE36/10L/Y10-5X3.PDF

http://www.ps.bam.de/DE36/10L/Y10-5X4.PDF

The right part of Fig. 2 is similar to the left part. Instead of a cyan blue output a bluish output is used.

http://www.ps.bam.de/DE36/10L/Y10-7X3.PS

http://www.ps.bam.de/DE36/10L/Y10-7X3.PDF

http://www.ps.bam.de/DE36/10L/Y10-7X4.PDF

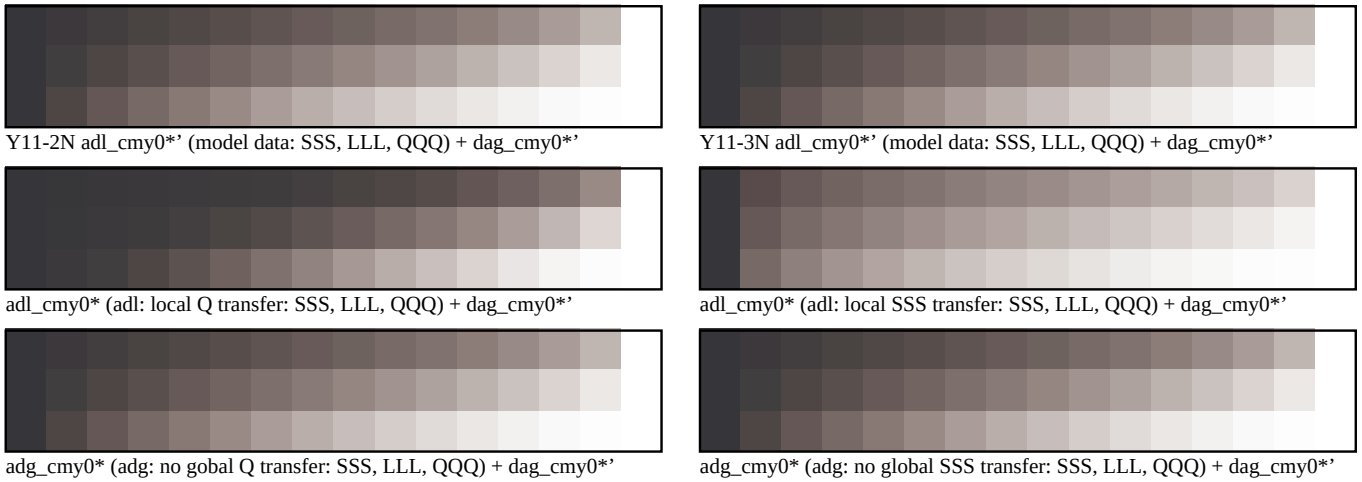

Figure 3: Three *cmy0 16 step gray scales; Linear (L), Quadratic (Q) and Square root (S) and modifications**

Fig. 3 is similar to Fig. 1 and shows three 16 step gray scales; Linear (L), Quadratic (Q) and Square root (S). Instead of the three component PS operator (3 colorimage for *olv**) the four component PS operator (4 colorimage for *cmy0**) is used.

http://www.ps.bam.de/DE36/10L/Y11-2X3.PS

http://www.ps.bam.de/DE36/10L/Y11-2X3.PDF

http://www.ps.bam.de/DE36/10L/Y11-2X4.PDF

The PS and PDF file output of Fig. 3 appears for many printers and monitors very different compared to Fig. 1 but according to colorimetry the same output is required. The difference of the PDF output depends on the software used, e. g. *Adobe Reader* or Mac Preview. In agreement to colorimetry the PS file output of Fig. 3 appears achromatic if a Display PostScript system is used. There is agreement with colorimetry for some PostScript printers.The PDF file output appears achromatic on the monitor if the software *Mac Preview* is used and brownish if the software *Adobe Reader* is used. If the software *Adobe Reader* is used for the printer output (on non PS printers) then there is often a brownish output.

1.2 olv*' and cmy0*' image output on monitors and printers and output correction

The solution of the problems is shown in the right Fig. 3 in the middle part. The three grey scales are transferred here by a **local** three channel **special** transfer function within the file. The brownish L scale is transferred to the standard achromatic L scale. The same special transformation (for the software *Adobe Reader* and the monitor output) produces the achromatic Q and S scales as intended.

We have determined the analog – digital – special data: ads: ads_olv*' and ads_cmy0*. We opened the *cmy0** PS file (left of Fig. 3) with the software Adobe Illustrator 8.0 on Macintosh. There is a tool “Pipette” which allows to see the *cmy0** data of each of the 16 grey patches on the screen. They are equally spaced between 0% and 100%. One can switch to see the *olv** (rgb) data for any grey sample. The *olv** data are very uneven spaced according to a special build-in transfer of the software Adobe Illustrator 8.0 between *cmy0** and *olv** (rgb). This olv*' table for the 16 greys is used for the local transformation which uses the inverse transformation separately for each of the three channels. The output in the right Fig. 3 appears achromatic and is within the intended tolerances of three units (0.47 to 0.53) for mean grey for any of the grey samples.

http://www.ps.bam.de/DE36/10L/Y11-3X3.PS

http://www.ps.bam.de/DE36/10L/Y11-3X3.PDF

http://www.ps.bam.de/DE36/10L/Y11-3X4.PDF

NOTE: The transformation may be different depending on the setting of the software. In Adobe Illustrator 8.0 for Macintosh the standard settings have been used: AI standard monitor, AI standard printer, Adobe CMS, relative colorimetry

The method of this paper is very important in many cases. In applications there is a wish to see the same colours on

the monitor independent of the corresponding colour space used

In conclusion:

The correponding colours produce **very different** output or **no output difference** on monitors and printers. Sometimes for the present **standard software** the monitor output is **very** different and there are **no** output differences on printers or vice versa.

Note: On most printers and monitors the output of this paper produces large color differences (often 15 CIELAB) if the PS or different PDF files are used for output. The large colour differences for corresponding colours of different colour spaces are **not** intended by users and CIE colorimetry. See the PS and the two PDF versions at

http://www.ps.bam.de/BAMIMAGE.PS

http://www.ps.bam.de/BAMIMAGE3.PDF

http://www.ps.bam.de/BAMIMAGE4.PDF

1.3 Possible reasons for the basic difference produced by different *Distiller* versions.

The software *Adobe Distiller 3.0 for Macintosh* includes three options to include the transfer functions in images:

Option no. 1: Remove Transfer Functions
Option no. 2: Preserve Transfer Functions
Option no. 3: Apply Transfer Functions

The software *Adobe Distiller 4.0 for Macintosh* includes **only the first two** options and the most important option no. 3 for many application is missing.

Option no. 1 ignores in the PDF files the transfer functions, e. g. the local transfer functions in Fig. 1 to 3 are not used for the PDF output.

Option no. 2 uses in the PDF files the transfer function for monitor output and **not** for PS printer output, e. g. the local transfer functions in Fig. 1 to 3 seem to be used by the monitor driver and **not** by the printer driver.

Note: This produces very artificial and confusing effects for any user. The correction of the brownish monitor output of *Adobe Reader* by a transfer function in Fig. 3 is seen on the monitor but there is no correction for the printer output, e. g. the printer output is the same with and without the transfer function but the monitor output is for both cases different.

Option no. 3 uses in the PDF files the transfer function for both the monitor and the PS printer output, e. g. the local transfer functions in Fig. 1 to 3 seem to be used by both the monitor driver and the printer driver.

Note: This property is required by most user. But exact this property is deleted in the software *Adobe Distiller* 4.0 which has only the options no. 1 and no. 2.

Therefore we have produced two PDF files 3.PDF and 4.PDF with the software *Adobe Distiller versions 3.0 and 4.0*. All the important transfer functions of Fig. 1 to 3 are deleted in the output of the file 4.PDF.

Note: Adobe Illustrator 8.0 allows to import both the PS file and the PDF file. The import of the corresponding PS and PDF files: 3.PDF (option **Apply** Transfer Function) and 4.PDF (option Preserve Transfer Function) gives very different results. In the file 4.PDF the transfer function is removed but this is the only option which exists for the software *Adobe Distiller 4.0 on Macintosh*. The files useful for study are:

http://www.ps.bam.de/DE36/10L/Y10-2X3.PS

http://www.ps.bam.de/DE36/10L/Y10-2X3.PDF

http://www.ps.bam.de/DE36/10L/Y10-2X4.PDF

One can download the above PS file and transfer the PS file by different versions of the software *Adobe Distiller* on different computer systems (Windows, Mac, Unix). The output of the PDF files on a printer may be very different by up to 15 CIELAB on the same platform.

Therefore the user needs to control the change of the properties between the PS and the PDF files. Therefore ISO/IEC-test charts are necessary. Only ISO/IEC-test chart files allow the printer industry and the users to locate the source of the property change. One can decide exactly if the unexpected result depends on the printer or the printer driver or the application software.

This paper includes many files which show many of the expected and unexpected properties. A user may ask the device or software company if a desired standard property is included. An ISO/IEC standard is a guide for the decision of a company which like to include or remove or change the image file properties.

Conclusion: Software which is in agreement with CIE colorimetry produces equal output on printers and monitors for the files of Fig. 1 to 3. **For corresponding colours the *olv** and the *cmy0** image data produce equal output.** There are three special inverse tone functions which can be used to correct unexpected output results of the software *Adobe Reader* 3.0 or 4.0 on the monitor.

1.4 olv*' and cmy0*' image output with 16 step scales on monitors and output correction

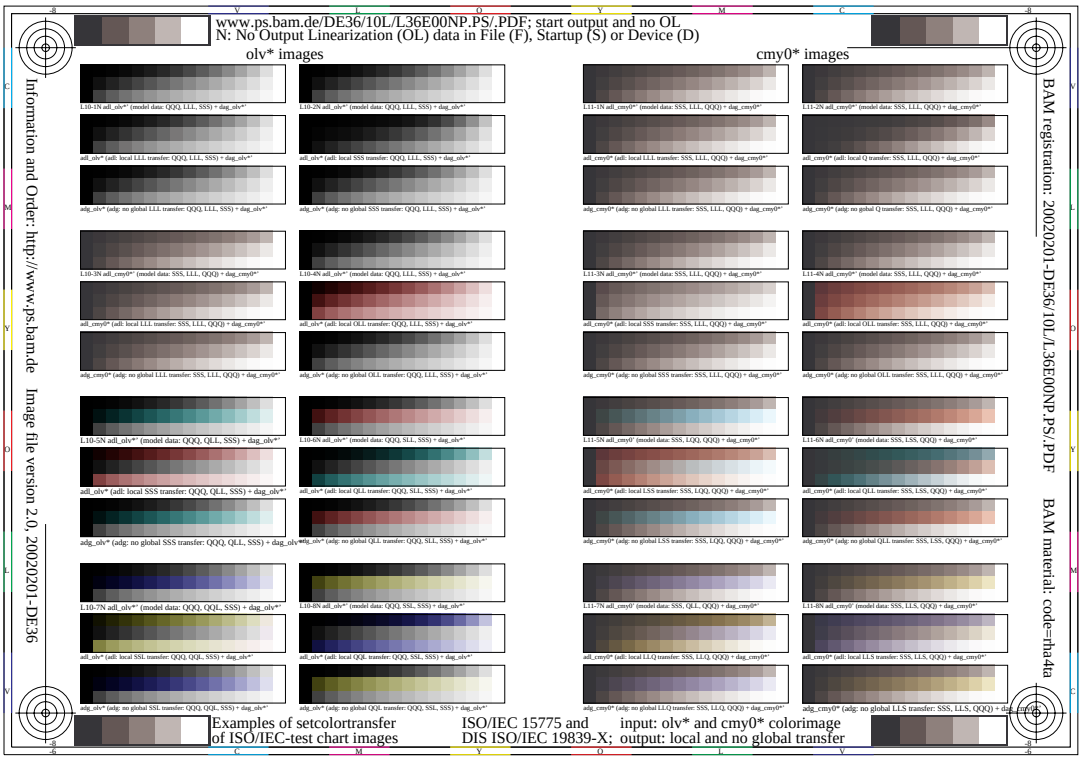

Figure 4: *olv and *cmy0** images with 16 step colour scales**

Fig. 4 shows on the left and right side 8 x 3 *olv** images and *cmy0** images. According to colorimetry it is required that the output on the left and right side is the same.The standard software, e. g. *Adobe Reader*, produce on the monitor a brownish right side and an achromatic left side. The output may depend on the platform (Mac, Win) and the software version of *Adobe Reader* and *Adobe Distiller* used. Other software, e. g. Mac Preview, produce equal output for the *olv** and *cmy0** images of the left and right sight. The file of Fig. 4 is at

http://www.ps.bam.de/DE36/10L/L36E00NP.PS

http://www.ps.bam.de/DE36/10L/L36E00NP.PDF

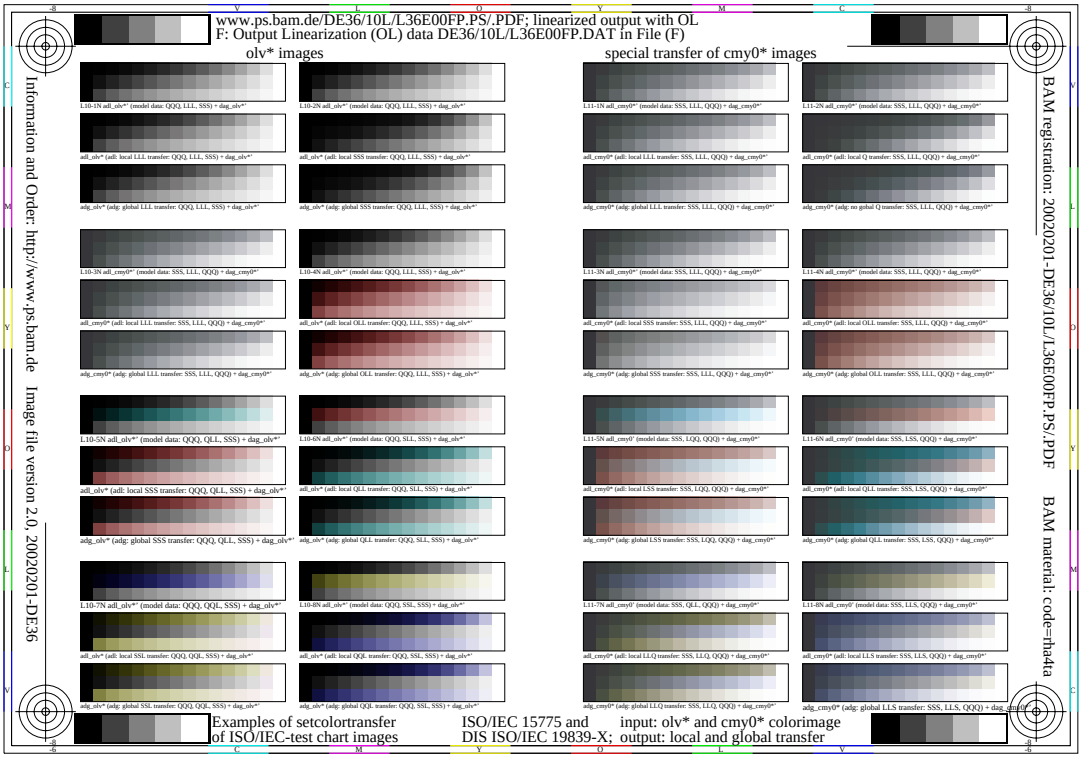

Figure 5: *olv and *cmy0** images with 16 step colour scales corrected for monitor output (right side)**

Fig. 5 shown the same colours compared to Fig. 4. The *cmy0** image output is now corrected by a (global) special transfer function. The procedure to determine this function is described earlier. The original file is at

http://www.ps.bam.de/DE36/10L/L36E00FP.PS

http://www.ps.bam.de/DE36/10L/L36E00FP.PDF

Note: There are some PS printers which show already for Fig. 4 (NP file) the same output for the *olv** and the corresponding *cmy0** images. In this case the correction used in Fig. 5 (FP file) produces a bluish green output for the *cmy0** images. The colours produced on printers with the intended properties are the opponent colours compared to the brownish output on the monitor.

2. Fig. B4 and D4 of ISO/IEC-test chart as image for output linearisation

The ISO/IEC-test charts no. 2. and no. 3 according to ISO/IEC 15775 include 16 step colour series between white and the six chromatic colours CMY and OLV and black N. The colours are defined by the PS operator setcmykcolor.

2.1 Output system test with Fig. B4 and D4 of ISO/IEC-test charts (whitish colours)

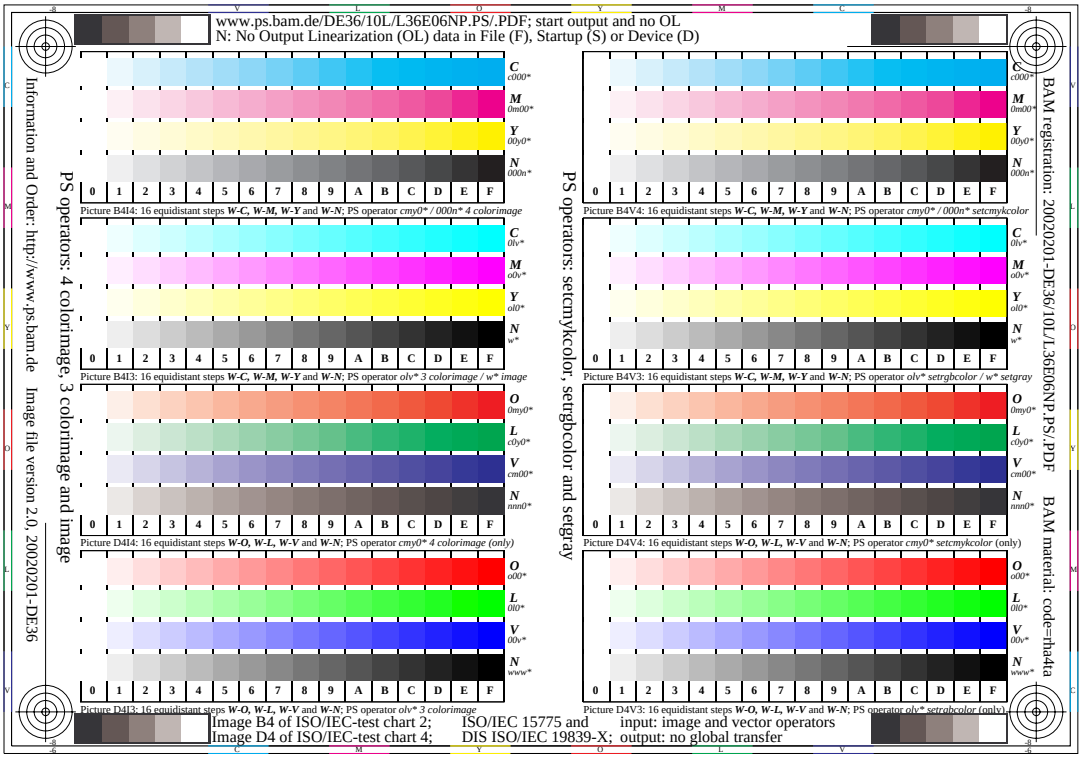

Figure 6: Vector and image PS operators to produce the 16 step series W – CMYOLV and W – N.

Fig. 6 shows the 16 step series W – CMYOLV and W - N. The series W – N is produced by different PS operators. On the left side different image operators and on the right side different vector operators (to fill e. g. a square with a colour) are used. For images (left side) the PS operators 4 colorimage, 3 colorimage and image are used. For vector graphic (right side) the PS operators setcmykcolor, setrgbcolor and setgray are used.

According to colorimetry it is required that on monitors and printers the four series W – CMYN and the four series W – OLVN appear equal. But there are large differences on printers and monitors and only some combinations of software and device produce the required equal output. With *Adobe Reader* and for monitor output the achromatic series in Fig. B4I4 (Image 4 component operator) and B4V4 (vector 4 component) differ from the other gray scales (about 15 CIELAB for mean grey).

Additionally the spacing is different for every device. But with the MTL code the spacing can be made equal. The intention is to get an equal and equally spaced output for the corresponding colours in different colour spaces. Aa accuracy of 3 CIELAB is intended. The original file which is very useful for every system test is at

http://www.ps.bam.de/DE36/10L/L36E06NP.PS

http://www.ps.bam.de/DE36/10L/L36E06NP.PDF

2.2 Output system test with Fig. B4N and D4N of ISO/IEC-test charts (blackish colours)

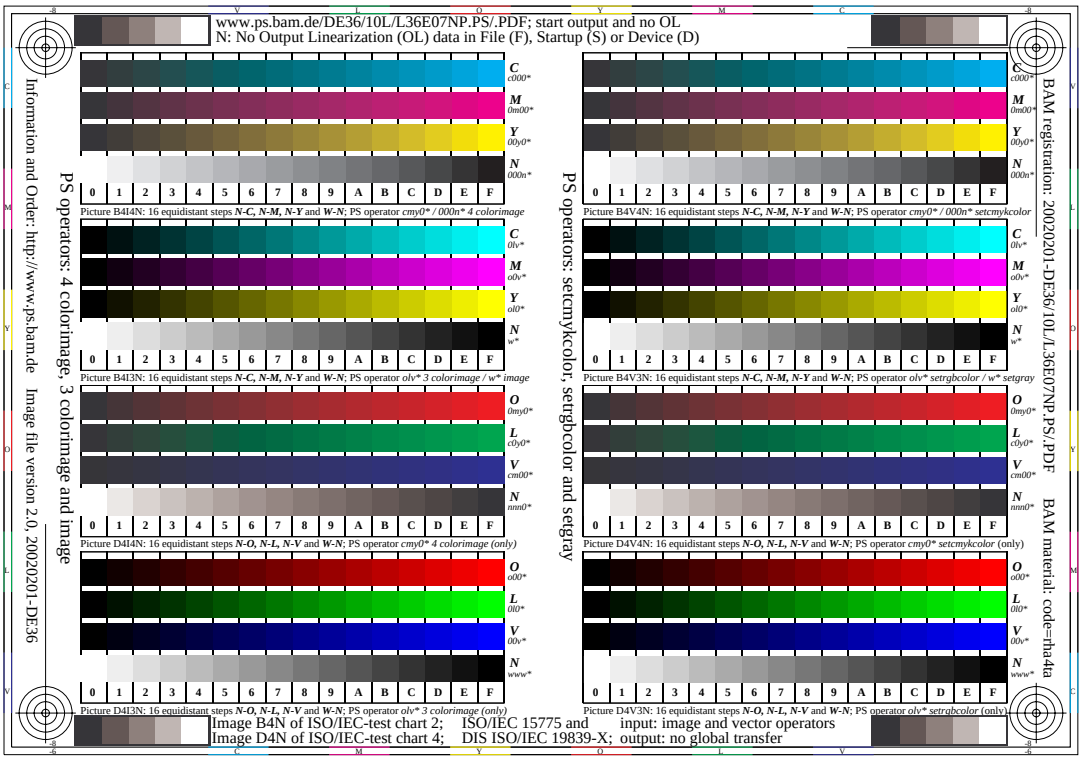

Figure 7: Vector and image PS operators to produce the 16 step series N – CMYOLV and W – N

Fig. 7 is similar to Fig. 6. Instead of the **whitish** series the **blackish** series are reproduced. A method to make this series equally spaced within 3 CIELAB can be added to the MTL code. But according to colorimetry one can expect that the series from black to colour, e. g. N – CMY, are approximately equally spaced if the achromatic series is equally spaced [4, page 91]. The equal spacing of the achromatic series is included in the MTL code. The file is at

http://www.ps.bam.de/DE36/10L/L36E07NP.PS

http://www.ps.bam.de/DE36/10L/L36E07NP.PDF

The output differences between the intended and the output colours are reduced by a factor 3 to 5 for the whitish 16 step colour series by the MTL code, see Annex of DIS ISO/IEC 19839-2 (printers) on the SC28 server. For many applications in design the whitish series are the more important.

The colours of the blackish series are highly influenced by the room illumination in the office and the surface reflection properties of the monitor. The ISO/IEC standard 19839-X tests the whitish colour series and all the experience up to now show that the 16 step spacing of the blackish colour series is acceptable if the spacing of the whitish series is acceptable. For the grey scale the spacing is the same.

3. Image output of 32 standard colours of ISO/IEC-test charts

The following figures show image data of an image which is used in the ISO/IEC-test chart no. 2 according to ISO/IEC 15775. The 32 colours are included in the file by hexadecimal data (similar as in Fig. 1 to 3). The hexadecimal scan data are produced by the standard Photo-CD process. For slide film the exposure was varied between under and over exposure (-1,5 stops to +1,5 stops), for negative film the exposure was varied between -2,0 stops and +4,0 stops. In this case the light in the film plane varies by a factor 64.

The standard 32 test colours of ISO/IEC 15775 have been included as physical samples in the taking flower motif. The hexadecimal image data have been extracted at the appropriate places by a FORTRAN program. The 32 *adl_olv*'* data (adl = analog – digital – local, **'* = star-dash) are included in the following files. Of course a software tool which can read the *adl_olv*'* scan data, e. g. Adobe Illustrator or Adobe Photoshop shows the same data. There is of course some scatter especially in the dark parts but this is not important here.

Important is to place the 32 *adl_olv*'* image data in front of the olv*' image. Then the data can be used e. g. for a local *adl_olv*'* image transfer. This image transfer is completely determined for the 16 grey steps. And in the colour field the correct reproduction of the 16 grey steps determine about 70% of the image quality. So for applications in offices in most cases **only** the correct reproduction of the 16 grey steps is essential.

3.1 Local colour transfer by slide film exposure variation between -1,5 and +1,5 stops

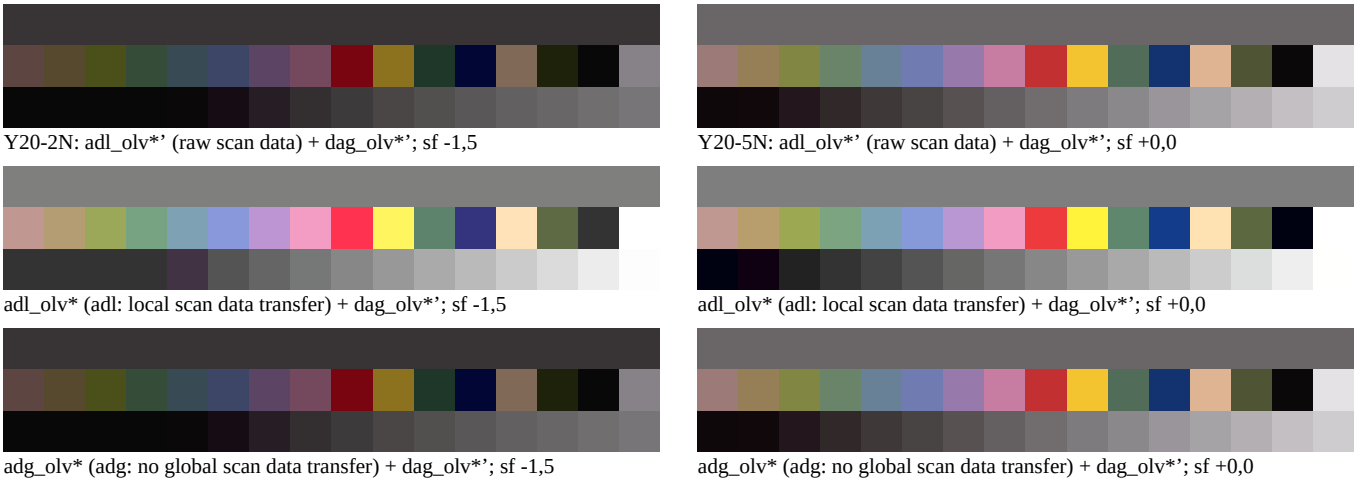

Figure 8: 32 olv*' ISO/IEC-test colours on slide film for the exposures -1,5 and +0.0 and modifications

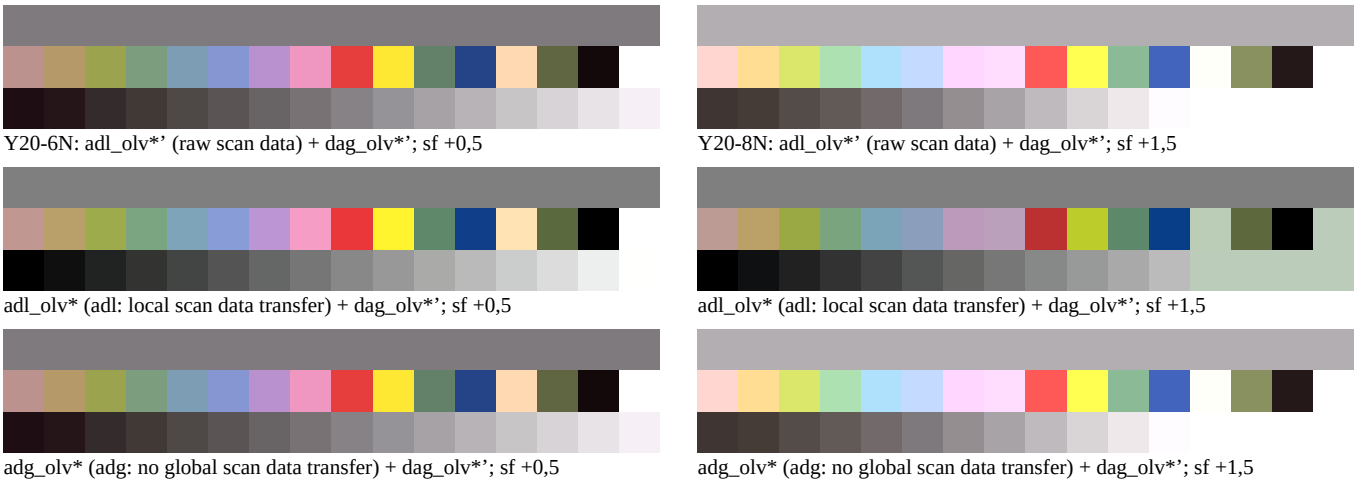

Figure 9: 32 olv*' ISO/IEC-test colours on slide film for the exposures +0,5 and +1,5 and modifications

The left Fig. 8 shows three times the raw scan data of the 32 ISO/IEC-test colours for the exposure -1,5 (under exposure). In the middle part the data are transferred by a **local** three channel inverse transfer function within the file. The bottom part is equal to the top part.

The right Fig. 8 shows a similar result for the exposure +0.0. Fig. 9 shows similar results for the exposures +0.5 and +1,5 (over exposure). The original files are at:

http://www.ps.bam.de/DE36/10L/Y20-2X3.PS

http://www.ps.bam.de/DE36/10L/Y20-2X3.PDF

http://www.ps.bam.de/DE36/10L/Y20-5X3.PS

http://www.ps.bam.de/DE36/10L/Y20-5X3.PDF

http://www.ps.bam.de/DE36/10L/Y20-6X3.PS

http://www.ps.bam.de/DE36/10L/Y20-6X3.PDF

http://www.ps.bam.de/DE36/10L/Y20-8X3.PS

http://www.ps.bam.de/DE36/10L/Y20-8X3.PDF

In the following instead of a **local** transfer a **global** transfer and an **external** transfer of the hexadecimal colour image data is intended. In the case of a **global** transfer only the *adl_olv*'* data will remain in the image file together with a PS statement

{ } { } { } { } setcolortransfer

This statement does not change the raw scan data output of the image file. The **global** MTL code uses instead of the first three empty procedures “{ }” three inverse tone functions which are determined by the *adl_olv*'* data before the hexadecimal image data.

3.2 Local colour transfer by negative film exposure variation between -2,0 and +4,0 stops

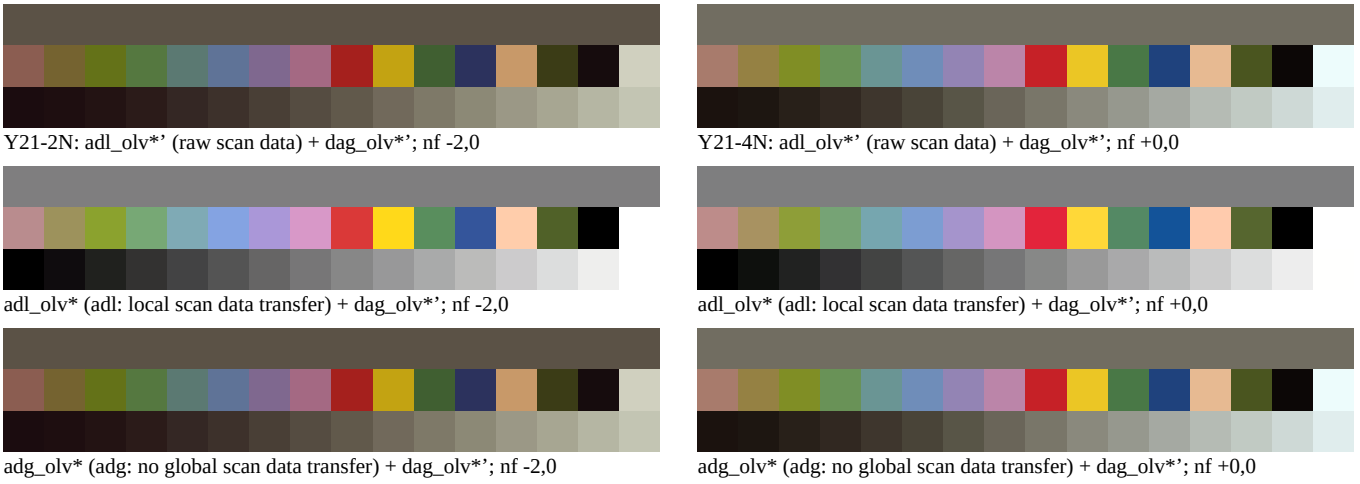

Figure 10: 32 olv*' ISO/IEC-test colours on negative film for the exposures -2,0 and +0,0 and local transfer

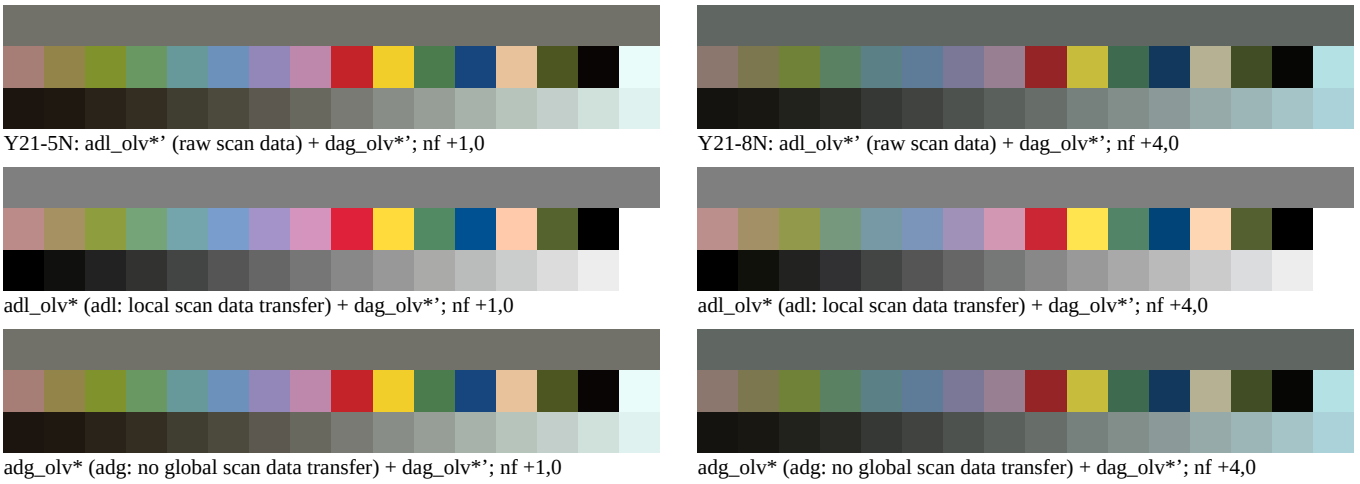

Figure 11: 32 olv*' ISO/IEC-test colours on negative film for the exposure +1,0 and +4,0 and local transfer

The left Fig. 10 shows three times the raw scan data of the 32 ISO/IEC-test colours for the exposure -2,0 (under exposure). In the middle part the data are transferred by a **local** three channel inverse transfer function within the file. The bottom part is equal to the top part.

The right Fig. 10 shows a similar result for the exposure +0.0. Fig. 11 shows similar results for the exposures +1,0 and +4,0. The original files are at:

http://www.ps.bam.de/DE36/10L/Y21-2X3.PS

http://www.ps.bam.de/DE36/10L/Y21-2X3.PDF

http://www.ps.bam.de/DE36/10L/Y21-4X3.PS

http://www.ps.bam.de/DE36/10L/Y21-4X3.PDF

http://www.ps.bam.de/DE36/10L/Y21-5X3.PS

http://www.ps.bam.de/DE36/10L/Y21-5X3.PDF

http://www.ps.bam.de/DE36/10L/Y21-8X3.PS

http://www.ps.bam.de/DE36/10L/Y21-8X3.PDF

The local transfer for negative film colours produces a very similar result compared to the local transfer of the slide film colours. The exposure range for approximately the same output is for negative film very large. The range limits for acceptable output are near -1,0 stops under exposure and +3,0 stops over exposure. The corresponds to a light range of 1:16 on the film plane. The method used here for input scan data transfer is very important. All other colour management methods fail, e. g. the ICC method, if variable processes occur. The scan data output depend to a high degree on the exposure but still the calculated hexadecimal image data produce equal output.

It is a large surprise that the **input light can vary by a factor 1:16 and still the output colour is approximately the same**. The output colour is **approximately independent of the film material** used.

3.3 Local and external transfer by negative film exposures between -2,0 and +4,0 stops

Y31-2N: adl_olv*’ (raw scan data) + dag_olv*’; nf -2,0

Y31-4N: adl_olv*’ (raw scan data) + dag_olv*’; nf +0,0

adl_olv* (adl: local scan data transfer) + dag_olv*’; nf -2,0

adl_olv* (adl: local scan data transfer) + dag_olv*’; nf +0,0

ade_olv* (ade: external scan data transfer) + dag_olv*’; nf -2,0

ade_olv* (ade: external scan data transfer) + dag_olv*’; nf +0,0

Figure 12: 32 olv*' ISO/IEC-test colours on negative film for the exposures -2,0 and +0,0 and external transfer

Y31-5N: adl_olv*’ (raw scan data) + dag_olv*’; nf +1,0

Y31-8N: adl_olv*’ (raw scan data) + dag_olv*’; nf +4,0

adl_olv* (adl: local scan data transfer) + dag_olv*’; nf +1,0

adl_olv* (adl: local scan data transfer) + dag_olv*’; nf +4,0

ade_olv* (ade: external scan data transfer) + dag_olv*’; nf +1,0

ade_olv* (ade: external scan data transfer) + dag_olv*’; nf +4,0

Figure 13: 32 olv*' ISO/IEC-test colours on negative film for the exposures +1,0 and +4,0 and external transfer

The left Fig. 12 shows three times the raw scan data of the 32 ISO/IEC-test colours by the exposure -2,0 (under exposure). In the middle part the data are transferred by a **local** three channel inverse transfer function within the file. The bottom part is equal to the middle part. He we have used an **external** transfer by a separate FORTRAN program which transfers the hexadecimal data in the same way as the local transfer (middle part). It is obvious that the bottom part and the middle part is identical.

The right Fig. 12 shows a similar result for the exposure +0.0. Fig. 13 shows similar results for the exposures +1,0 and +4,0 (large over exposure). Even in this case the output of the 16 grey steps and the colours is acceptable. The original files are at:

http://www.ps.bam.de/DE36/10L/Y31-2X3.PS

http://www.ps.bam.de/DE36/10L/Y31-2X3.PDF

http://www.ps.bam.de/DE36/10L/Y31-4X3.PS

http://www.ps.bam.de/DE36/10L/Y31-4X3.PDF

http://www.ps.bam.de/DE36/10L/Y31-5X3.PS

http://www.ps.bam.de/DE36/10L/Y31-5X3.PDF

http://www.ps.bam.de/DE36/10L/Y31-8X3.PS

http://www.ps.bam.de/DE36/10L/Y31-8X3.PDF

In summary: The output of the 32 ISO/IEC-test colours appears visually **identical** for normal exposure of **slide and negative film**. For slide film between -0.5 stops under exposure and +1.0 stops over exposure and for negative film between -1,0 stops under exposure and +3,0 stops over exposure the output is approximately identical. **Therefore the output appears approximately equal for a large variety of film material, exposure variation and taking**

illuminant (not varied here).

4. Local, global and external transfer of ISO/IEC-test chart images

It is intended to show the all the scan data and the transfer for slide and negative film for the different exposures on one page and additionally to transfer the raw scan data of the third sub figure by a **global** and **external** transfer.

4.1 Local transfer of the colour image data in ISO/IEC-test chart images

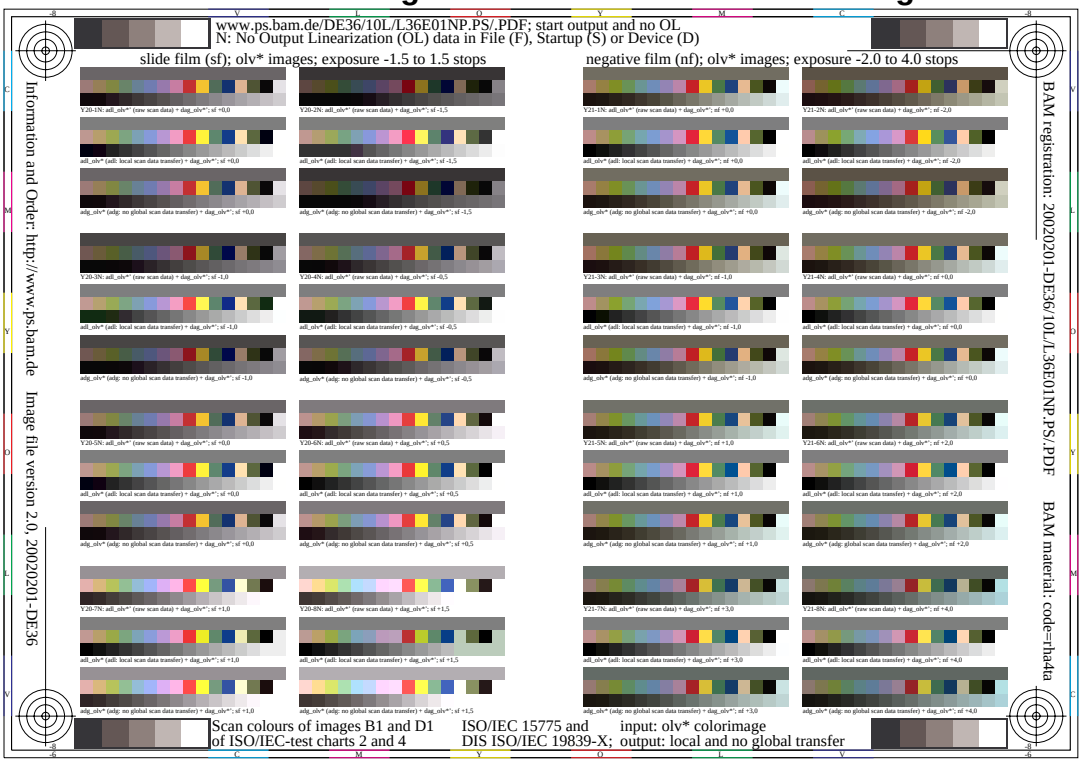

Figure 14: Local transfer of ISO/IEC-test chart colours for slide and negative film by exposure variation

4.2 Global transfer of the colour image data in ISO/IEC-test chart images

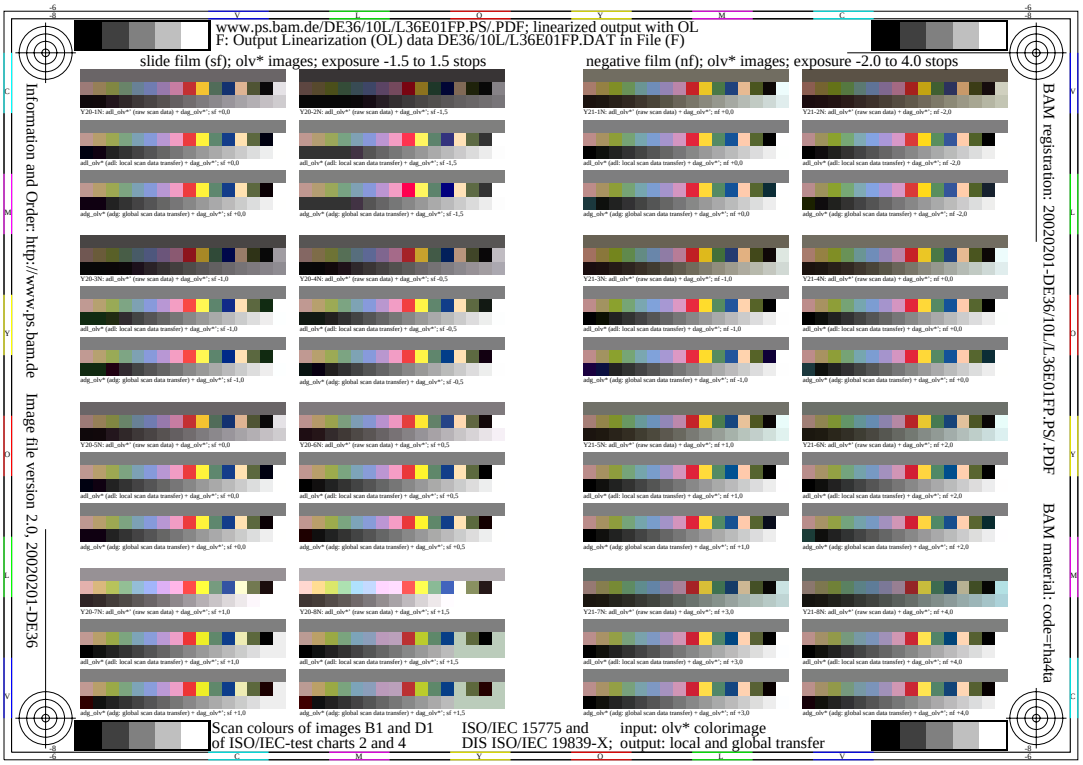

Figure 15: Global transfer of ISO/IEC-test chart colours for slide and negative film by exposure variation

In Fig. 14 the output for slide and negative film and for the seven exposures is shown on one page. There are three sub figures in each of the sixteen figures. Each of these sub figures includes the same raw scan image data and the 32 *adl_olv*'* data in a table before the hexadecimal image data.The upper and the lower sub figure is the same. In the middle the colours are transferred by a **local** image transfer and this image transfer produces approximately the same output for a large variety of exposure variations and the two film materials. The original file is at

http://www.ps.bam.de/DE36/10L/L36E01NP.PS

http://www.ps.bam.de/DE36/10L/L36E01NP.PDF

In Fig. 15 the lower sub figure data are transferred by a **global** image transfer. It appears the **same output** as for the **local** image transformation. The global image transfer is defined in the MTL code. The MTL code uses the 32 *adl_olv*'* data table if the data are present in front of the hexadecimal image data. The original file is at

http://www.ps.bam.de/DE36/10L/L36E01FP.PS

http://www.ps.bam.de/DE36/10L/L36E01FP.PDF

In Fig. 15 the individual change of the colours is done by only **one global transfer function.** For this the individual 32 *adl_olv*'*'data (or at least 16 data) must be included in the file in front of the image data. If the exposure is constant then the 32 *adl_olv*'*'data may be included in the MTL code and are not necessary in the image files.

The **global** transfer is included in the MTL code. If the 32 *adl_olv*'* (at least 16 *adl_olv*'* grey) data are present in a file then the MTL code uses exactly this file data and produces the intended output. In this case the mathematics of the **global** transfer is the same compared to the local transfer. The global transfer uses the individual *adl_olv*'* image data of the file. This transfer is of course different for all the slide and the negative film images for the different exposures.

4.3 External transfer of the colour image data in ISO/IEC-test chart images

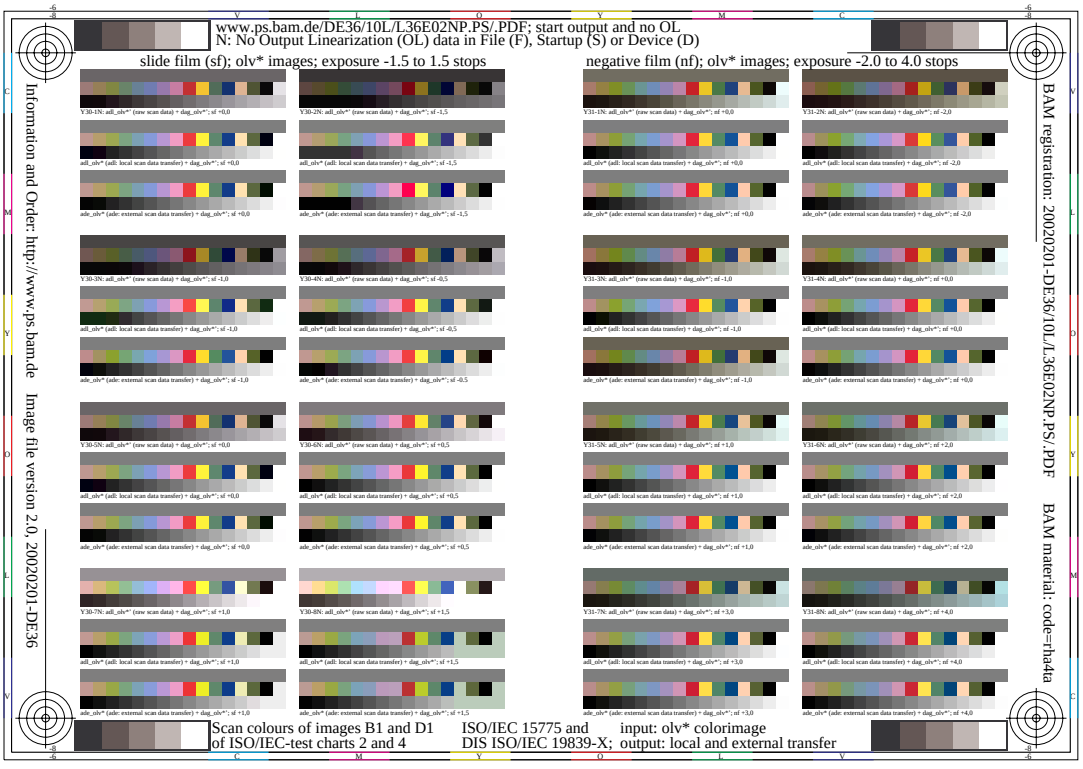

Figure 16: External transfer of ISO/IEC-test chart colours on slide and negative film by exposure variation

Fig. 16 produces for the lower sub figure the same output by an **external** image transfer compared to the **global** image transfer in Fig. 15 and the **local** image transfer of Fig. 16 (middle part). The external image transfer is defined by the same procedure compared to the MTL code. The external image transformation uses the 32 *adl_olv*'* data table to calculate new hexadecimal image data. The new hexadecimal image data are included in the file code of the lower sub figure. The original file is at

http://www.ps.bam.de/DE36/10L/L36E02NP.PS

http://www.ps.bam.de/DE36/10L/L36E02NP.PDF

4.4 Global transfer for the flower motif of the ISO/IEC-test chart (image B1 or C1)

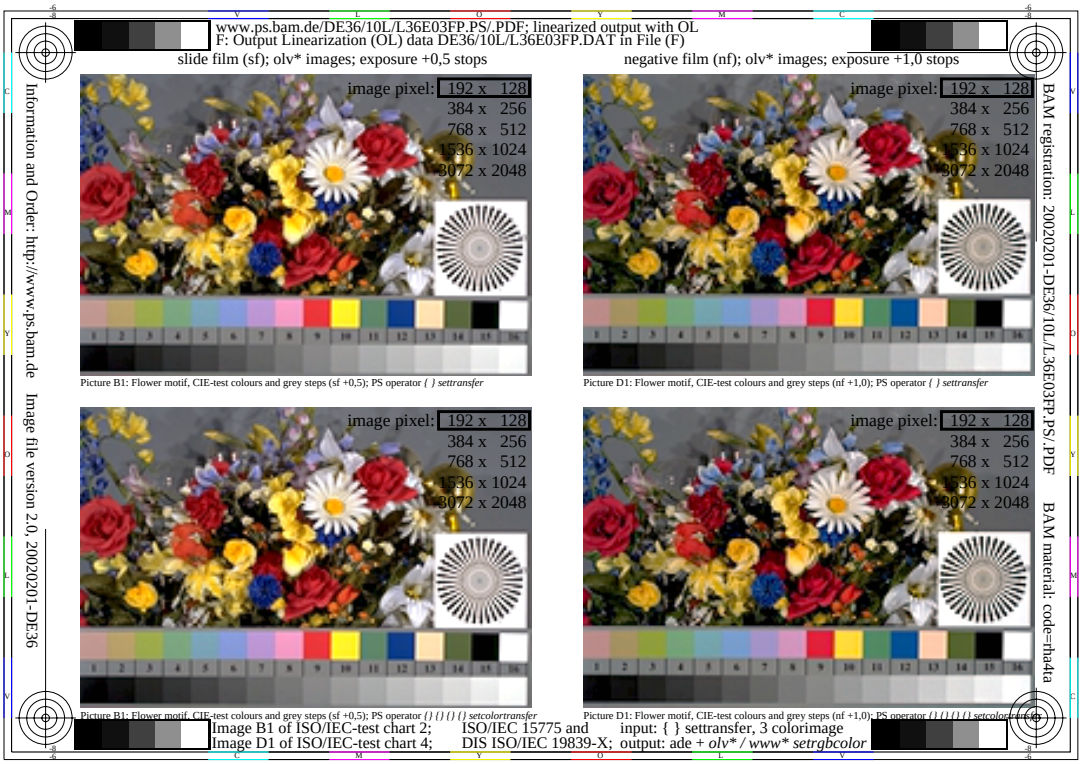

Figure 17: Global transfer of ISO/IEC-test chart colours on slide and negative film by best exposure

Fig. 17 shows an application for the whole flower image. The raw scan image data are transferred by a global image transformation. This image transformation uses the 16 *adl_olv*'* image (green) data in front of the hexadecimal raw scan image data. The lowest resolution is used here to avoid a large file size of this paper. The original file is at

http://www.ps.bam.de/DE36/10L/L36E03FP.PS

http://www.ps.bam.de/DE36/10L/L36E03FP.PDF

Conclusions

Corresponding colours of the *olv** and *cmy0** colour spaces (described by the **PS image operators** "4 colorimage, 3 colorimage and image" and described by the **PS vector graphic operators** "setcmykcolor, setrgbcolor and setgray") show in a lot of cases equal output as required by users and colorimetry. For many software – hardware combinations the colour defined in the *olv** and *cmy0** colour spaces appear **very different** (about 15 CIELAB). An example is the software *Adobe Reader* which produces a brownish output on the monitor for the greys defined in the *cmy0** colour space.

A digital ISO/IEC-test chart uses the **six different PS operators** on one page. This test chart (Fig. 6) is used for a system test (combinations of hardware and software) of the device colour output. For this test the 16 step colour scales in Fig. B4 and D4 of the ISO/IEC-test chart according to ISO/IEC 15775 are used.

If in the output different results appear for the different software products on the different devices then the user can make the appropriate decisions according to his requirements. In many cases a user with some technical knowledge can correct the output with the MTL code, e. g. if for examples the colours are specified in the *cmy0** colour space a global special transfer for the *Adobe Reader* output on the monitor may be used. With this special transfer the *olv** and *cmy0** output appears equal on the monitor.

A local, global or external transfer is used to make the output of raw scan image data of **slide** and **negative** film very similar. A large variation of exposure has no influence on the output. There seem to be no other method with this property. For slide films the exposure range is between about -0,5 stops (under exposure) and +1,0 stops (over exposure). For negative films the exposure range is between about -1,0 stops (under exposure) and +3,0 stops (over exposure). The output appears the same for a local and external transfer. All the different exposures of two film materials are shown on one page for the local, global and external transfer. The global transfer is applied to an image of the flower motif (Fig. B1 and D1 of ISO/IEC-test chart according to ISO/IEC 15775).

Remarks: The example solutions with the FP files of the ISO/IEC-test charts help users and manufacturers and will appear in an ISO/IEC technical report (already approved in ISO/IEC JTC1/SC28) with K.Richter as Editor. The method with the MTL code is **not** intended to replace colour management methods of professional graphics but it

may be used to improve the output, e. g. to adapt the results to output paper and other variations.

5. References

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