TECHNICAL SPECIFICATION

ISO/TS 19264-1

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Photography — Archiving systems — Image quality analysis —

Part 1: Reflective originals

Photographie — Systèmes d'archivage — Analyse de la qualité d'image —

Partie 1: Documents réfléchissants

Reference number
ISO/TS 19264-1:2017(E)

3.1
acutance
numerical value that correlates to some extent with subjective image sharpness

[SOURCE: ISO 19262:2015, 3.1]

3.2
Adobe RGB 1998
three-component colour image encoding defined in Adobe RGB (1998) colour image encoding

Note 1 to entry: Adobe RGB 1998 Colour Image Encoding can be found under the following URL https://www.adobe.com/digitalimag/pdfs/AdobeRGB1998.pdf

[SOURCE: ISO 12640-4:2011, 3.1, modified — addition of the Note 1 to entry.]

3.3
banding
imaging
unwanted stripes or bands that occur in a digital image

Note 1 to entry: Note1 to entry: Bands are usually caused by fixed pattern noise of sensors in scanners, interference problems between electronic parts of a camera, or by too-coarse quantization.

[SOURCE: ISO 19262:2015, 3.9, modified — addition of "or by too-coarse quantization" in the Note 1 to entry.]

3.4
checkerboard
regular squared dark and bright structure on a surface like the one used on a chess board

[SOURCE: ISO 19262:2015, 3.18]

3.5
chroma, C*
chromatic
chromaticness, colourfulness, of an area judged as a proportion of the brightness of a similarly illuminated area that appears white or highly transmitting

[SOURCE: ISO/IEC 8613-2:1995, 3.18]

3.6
CIELAB colour space
three-dimensional, approximately uniform colour space, produced by plotting, in rectangular coordinates L^*, a^*, b^*

Note 1 to entry: This colour space has been designed to be device independent.

[SOURCE: CIE Publication 15 and ISO/IEC 5631-1:2015, 3.6, modified — Note 1 to entry has been modified.]

3.7
colour
sensation resulting from the visual perception of radiation of a given spectral composition

[SOURCE: ISO 4618:2014, 2.58, modified — definition slightly changed and Note 1 and Note 2 to entry have been deleted.]

3.8
colour difference
distinction between two colours observed or measured under standard conditions

[SOURCE: ISO 12637-2:2008, 2.21]

3.9
colour encoding
generic term for a quantized digital encoding of a colour space, encompassing both colour space encodings and colour image encodings

[SOURCE: ISO/TS 22028-3:2012, 3.6]

3.10
colour misregistration
colour-to-colour spatial dislocation of otherwise spatially coincident colour features of an imaged object

[SOURCE: ISO 19262:2015, 3.42]

3.11
contrast
difference between the grey levels of two specified parts of the image

[SOURCE: ISO 21227-1:2003, 3.5.3]

3.12
pixel defect
pixel or subpixel that operates in a way other than the one in which it is driven

[SOURCE: ISO 9241-302:2008, 3.4.30]

3.13
ΔE
see colour difference

[SOURCE: ISO 19262:2015, 3.63]

3.14
digital image
digital file consisting of picture elements (pixels) with one or more digital code values per pixel that represent a colour or tonal value

[SOURCE: ISO 19262:2015, 3.73, modified — deletion of the Note 1 to entry.]

3.15
digital imaging
process of creating digital images

Note 1 to entry: The term can also be used more generally to include digital image processing.

[SOURCE: ISO 19262:2015, 3.74]

3.16
digital imaging system
system that records and/or produces images using digital data

[SOURCE: ISO 12231:2012, 3.38]

3.17
digital still camera
DSC
device which incorporates an image sensor and produces a digital signal representing a still picture

Note 1 to entry: A digital still camera is typically a portable, hand-held device. The digital signal is usually recorded on a removable memory, such as a solid-state memory card or magnetic disk.

[SOURCE: ISO 12231:2012, 3.40]

3.23
gain modulation
variation of the gain over the signal level

Note 1 to entry: One example for a gain modulation is the application of a gamma to an image.

[SOURCE: ISO 19262:2015, 3.109]

3.24
gray scale
grey scale pattern
test chart consisting of test pattern based on spectrally neutral or effectively spectrally neutral, and consists of a large number of different reflectance or transmittance values in a prescribed spatial arrangement

Note 1 to entry: Grey scale patterns are typically used to measure opto-electronic conversion functions.

3.25
horizontal resolution
resolution value measured in the longer image dimension, corresponding to the horizontal direction for a “landscape” image orientation, typically using a vertically oriented test-chart feature

[SOURCE: ISO 12231:2012, 3.65]

3.26
ICC profile
International Colour Consortium’s file format, used to store transforms from one colour encoding to another, e.g. from device colour coordinates to profile connection space, as part of a colour management system

[SOURCE: ISO 22028-1:2016, 3.24]

3.27
image quality
impression of the overall merit or excellence of an image, as perceived by an observer neither associated with the act of photography, nor closely involved with the subject matter depicted

Note 1 to entry: The purpose of defining image quality in terms of third-party (uninvolved) observers is to eliminate sources of variability that arise from more idiosyncratic aspects of image perception and pertain to attributes outside the control of imaging system designers.

[SOURCE: ISO 20462-1:2005, 3.5]

3.28
limiting resolution
value of that portion of a specified resolution test pattern, measured in line widths per picture height, which corresponds to an average modulation value equal to some specified percentage of the modulation value at a specified reference frequency

Note 1 to entry: The limiting resolution could be the test pattern value, in line widths per picture height (w_l/h_p), corresponding to a camera output modulation level of 10 % of the camera output modulation level at a reference frequency of 10 w_l/h_p.

3.29
maximum modulation
maximum value of the spatial frequency response

Note 1 to entry: Maximum modulation is an indicator for applied sharpening.

3.41
resolution
theoretical resolution
limiting resolution
measure of the ability of a camera system, or a component of a camera system, to depict picture detail

Note 1 to entry: Resolution measurement metrics include resolving power, limiting resolution, special frequency response (SFR), MTF and OTF.

[SOURCE: ISO 12233:2017, 3.22, modified — Two new terms and a Note 1 to entry have been added.]

3.42
RGB
additive process colour model where the channels are called Red, Green and Blue

[SOURCE: ISO 15930-7:2010, 3.25]

3.43
sampling efficiency
ratio of the measured limiting resolution and the Nyquist frequency

Note 1 to entry: Both values need to have the same unit.

[SOURCE: ISO 19262:2015, 3.220]

3.44
sampling rate
number of samples per unit of time, angle, revolutions or other mechanical, independent variable for uniformly sampled data

[SOURCE: ISO 18431-1:2005, 3.13]

3.45
scanner
electronic device that converts a fixed image, such as a film or film transparency, into an electronic signal

[SOURCE: ISO 21550:2004, 3.19]

3.46
scene referred image state
image state image state associated with image data that represents estimates of the colour-space coordinates of the elements of a scene

Note 1 to entry: When the phrase "scene-referred" is used as a qualifier to an object, it implies that the object is in a scene referred image state. For example, scene-referred image data are image data in a scene-referred image state.

Note 2 to entry: Scene-referred image data can be determined from raw DSC image data before colour-rendering is performed. Generally, DSCs do not write scene-referred image data in image files, but some do so in a special mode intended for this purpose. Typically, DSCs write standard output-referred image data where colour-rendering has already been performed.

Note 3 to entry: Scene-referred image data typically represents relative scene colourimetry estimates. Absolute scene colourimetry estimates can be calculated using a scaling factor. The scaling factor can be derived from additional information such as the image OECF, F-number or ApertureValue, and ExposureTime or ShutterSpeedValue tags.

Note 4 to entry: Scene-referred image data can contain inaccuracies due to the dynamic range limitations of the capture device, noise from various sources, quantization, optical blurring and flare that are not corrected for, and colour analysis errors due to capture device metamerism. In some cases, these sources of inaccuracy can be significant.

4.5 White balancing

The white balance shall be measured on a grey card or a white card (without optical brighteners) to ensure correct and consistent results. This grey reference is required to be spectrally neutral in reflection and the surrounding shall not have a dominating colour. These settings shall be stored and used for production afterwards. This process shall be repeated on a regular basis to compensate for the spectral change of the light source over its lifetime. Depending on the type of light source the interval in which this needs to be done varies.

White balance performed on different tonal levels can vary. Highlights are generally more sensitive to errors. To check the variances of a system, it is best to use a grey scale and try different tonal levels.

4.6 ICC Profiling

If the originals are captured using a colour imaging system, an ICC profile should be created to characterize the system. For the purpose of ICC profiling, an ideal colour test chart reflects the type of originals to be digitized in terms of matching material and colourants.

If the software does not support ICC colour management, it is critical to determine if the system sensor, or any internal calibration, reaches accurate colour reproduction in the desired encoding before you decide to purchase or use the system.

4.7 Focusing

The system shall correctly be focused on the original. It depends on the tools the system has available how a good focus level can be achieved. Auto focus systems are often not reliable and may have problems focusing on certain originals without the introduction of focus aids.

4.8 Colour encoding

The desired colour encoding should be selected based on the intended application requirements and workflow preferences. In ISO 22028-1:2016, Annex B lists the characteristics and source standards for a number of standard colour encodings and Annex C provides criteria for selection of colour encodings.

In general, original- and scene-referred encodings are most appropriate for digital archiving systems. Examples of original-referred images are provided in ISO 12640-3, and examples of scene-referred images are provided in ISO 12640-5. However, at the time of the drafting of this document, very few scanners and digital cameras or raw processing applications supported either original- or scene-referred encodings, making it necessary to adapt output-referred encodings to this use.

When adapting output-referred encodings for the purpose of digital archiving, several changes to normal practice should be made in the processing, encoding, interpretation and display of the image data:

a) When processing the image data for encoding, any colour rendering should be turned off to the extent possible, so that the image colourimetry encoded accurately represents the colourimetry of the original object, with chromatic adaptation to the encoding white point. Particular attention should be paid to processing controls that apply nonlinear tone reproduction, or black or white clipping.

b) If it is not possible to turn off the colour rendering in the processing, profiling should be used to undo it to the extent possible, and the resulting profile assigned to the image, instead of the profile normally associated with the colour encoding used. For example, if a camera captures an Adobe RGB image, and the scanner or camera has been profiled, which this document recommends, the profile assigned to the image should be the appropriate scanner or camera profile rather than the Adobe RGB profile.

It should be noted that most output-referred RGB encodings use encoding 0 to represent the encoding reference medium black point, as opposed to an absolute black. This can cause several problems:

— In some cases, converting to the encoding could result in clipping of tones darker than the reference medium black point, which should be avoided. When original- or scene-referred images are stored using output-referred encodings, the reference medium should be ignored, and encoding 0 should be considered to represent absolute black.

— Likewise, in some cases converting from an output-referred encoding could cause a lightening of the dark tones, if the code values are interpreted as representing colours above the encoding reference medium black, as opposed to above absolute black.

— When displaying images, operating systems and application software may apply black point compensation, where the encoding black point is scaled to the display black point. This may be desirable in some cases, even with digital archive images, to avoid clipping of tones darker than the display black point. However, it should be noted that when black point compensation is applied, the dark tones will be displayed somewhat lighter and with lower contrast than they appear on the original. Applications with sophisticated colour management interfaces may offer the option to turn black point compensation on or off. However, it should also be noted that many display profiles set the display black point to 0, in which case turning black point compensation off will still not result in correct rendition of the dark tones.

Hopefully in the future support for original- and scene-referred colour encodings will become more widespread, avoiding most of these issues.

4.9 Reproduction scale

If a camera system with an area sensor is used the reproduction scale depends on the focal length as well as the object distance. This may need to be adjusted in the final image.

5 Imaging system quality analysis procedure

To determine the quality of an imaging system according to this document one or more test charts as described in the Annexes A and C needs to be digitized with the system that has been set up and calibrated according to the aspects described in the previous paragraph.

The digital image is then analysed according to the individual quality aspects mentioned in Clause 6. For some of the measurement procedures (e.g. Colour reproduction) reference data for the test chart is required. There are commercially available software tools that can do the analysis.

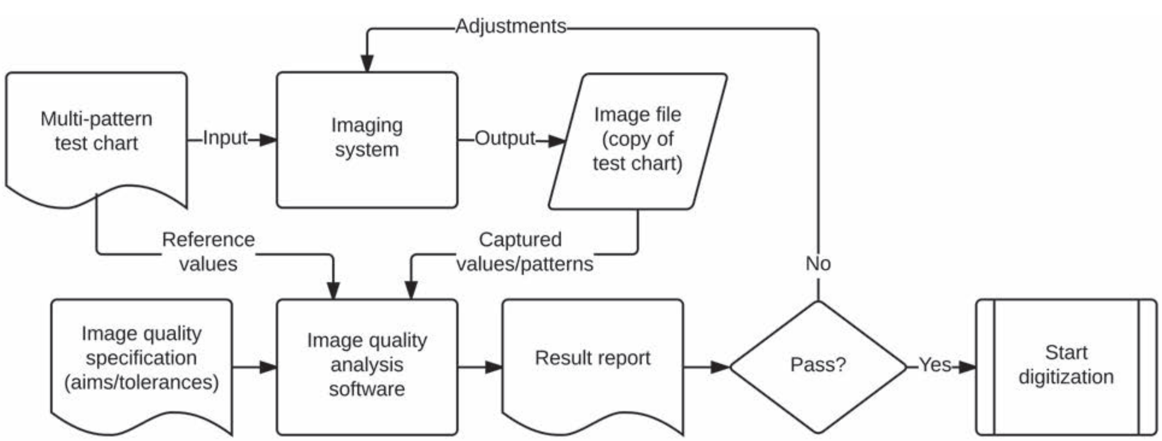

Figure 1 — Schematic representation of imaging systems quality analysis procedure

Characteristic	**Colour reproduction**
Description	The difference between selected physically measured input colours and their intended output rendering for a given colour space. This expresses how well an imaging system captures and encodes colours. In digital cameras colours are captured and encoded as combinations of Red (R), Green (G) and Blue (B). The colour encoding selected describes how these RGB values are related to CIELab values. Since none of the cameras or scanning systems matches the colour matching functions of the human visual system, the colour reproduction can strictly speaking only be optimal for a specific set of colours for which the system has been calibrated (profiled). Currently there are only two sets of commonly used colours to profile scanners and cameras. One is the IT8 Target according to ISO 12641 and the other one is the ColourChecker SG (Semi Gloss surface) target. However there are other targets that are available and may be used. After profiling the system by using these targets the targets are scanned again and the colour difference is measured using CIE ΔE 2000 (CIE 015:2004) approach with $SL = 1$ (ΔE 2000 SL1) which gives equal weight to the entire grey scale. The mean and max ΔE 2000 values for all patches shall be determined.
Related standards	CIE 15
Measurement	CIELAB colour difference measure (ΔE) according CIE 15 specs.
Reference target	Colour patches of Target defined in Annex A.
Aim	The smaller the colour differences ΔE (L^*a^*b) the more accurate the colour reproduction.
Notes	This measurement only provides useful information if the system has been calibrated and profiled correctly for colour reproduction. It does not provide a colour reproduction quality estimation for other than the chart colours and may show inaccurate colour reproduction for certain types of originals. For monitoring the system with a test chart other than the above-mentioned profiling charts a reference scan can be made using the chart described in Annex A right after the verification. Each monitoring scan can then be compared to the reference scan.

Characteristic	**Colour mis-registration**
Description	Colour-to-colour spatial dislocation of otherwise spatially coincident colour features of an imaged object.
Related standards	ISO 12233 (resolution measurement) ISO 19084 (chromatic displacement)
Measurement	Determination of edge location on a per channel basis for all slanted edges over the imaging field.
Reference target	Slanted edges in the test chart defined in Annex A.
Aim	Geometric distance between the edge location in the different colour channels shall be as small as possible.
Notes	If a dislocation of the edges in different colour channels is uniform over the field a standard colour mis-registration is present. If it varies over the field e.g. from centre to corners a chromatic aberration is present. For a line scanner it may be visible in just one direction. For a line scanning system there may also be a dislocation that comes and goes due do inconsistent motion.

Table 4 *(continued)*

Original L^*	White balance C^*
35	0,97
30	0,45
25	0,21
20	0,35
15	0,02
10	0,25
5	0,30
max	1,91
mean	0,54

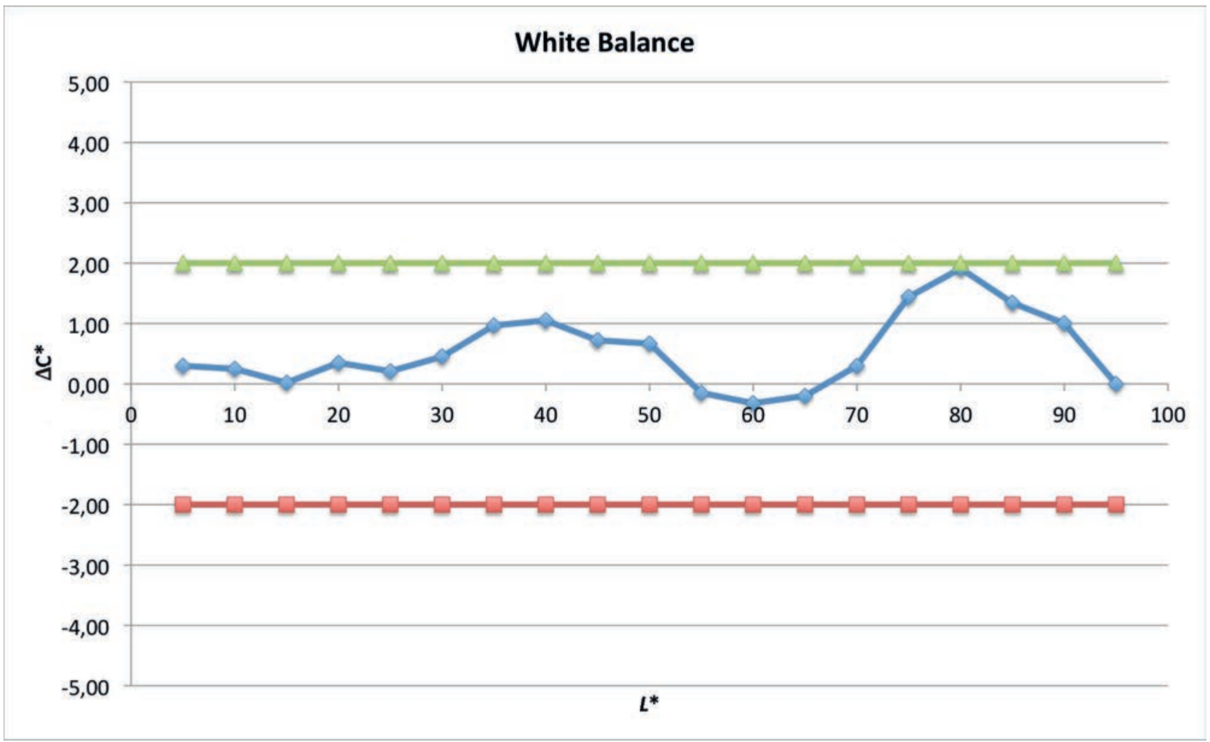

Figure 7 — Graphical representation of the white balance over the L^* value with the upper and lower tolerance levels

7.9 Colour reproduction

For the colour reproduction the ΔE 2000 values should be reported in form of a table for each individual patch together with the result for the mean and the max value for all patches.

It is sufficient to report the mean and the max value only, see Table 4.

Table 4 — Colour reproduction values

Colour Checker SG	mean ΔE	max ΔE
results	2,34	5,2

Annex B
(normative)

Guidelines for imaging performance aims and tolerances

Depending on the application each quality aspect may be of different importance, e.g. if a book is scanned to apply an OCR to it and make it inducible and searchable the colour accuracy is of minor importance and a high tolerance can be accepted. Therefore this document creates three quality levels for each of the characteristics. Users may combine the different quality levels they require for each characteristic to a full set of specifications.

For a manufacturer to advertise a level A compliant device according to this document the device shall be within all aim and tolerances stated for level A devices.

	Level A	**Level B**	**Level C**
Tone reproduction (of gray scale next to image centre)	$\Delta L^* \leq \pm 2$	$\Delta L^* \leq \pm 3$	$\Delta L^* \leq \pm 4$
Gain Modulation highlights Patches (L^*between 95 and 85*) (of gray scale next to image centre)	Gain between 0,8 and 1,1	Gain between 0,7 and 1,2	Gain between 0,6 and 1,3
Gain Modulation all other Patches (of gray scale next to image centre)	Gain between 0,7 and 1,3	Gain between 0,6 and 1,4	Gain between 0,3 and 1,6
Noise (visual noise)	<5	<6	<7
Dynamic range (of gray scale next to image centre)	≥2,3	≥2,1	≥1,9
Banding	Based on visual inspection, no banding	Based on visual inspection, no banding	Based on visual inspection, slight banding
Defect pixels (flat field illumination required)	No defects measureable	Less than 0,1 per million	Less than 1 per million
White balance (over field)	$\Delta C^* \leq \pm 2$	$\Delta C^* \leq \pm 3$	$\Delta C^* \leq \pm 5$
Colour reproduction	Max ΔE^* is recommended to be ≤ ± 10 Mean $\Delta E^* \leq \pm 4$	Max ΔE^* is recommended to be ≤ ± 15 Mean $\Delta E^* \leq \pm 5$	Max ΔE^* is recommended to be ≤ ± 15 Mean $\Delta E^* \leq \pm 5$
Sampling rate (Difference between claimed and obtained)	≤2 %	≤3 %	≤4 %
Resolution measured as frequency where 10 % Modulation is reached (MTF10) according to ISO 16067-1 at each location in the image and in both directions horizontal / vertical	≥85 % of claimed Sampling rate	≥80 % of claimed Sampling rate	≥70 % of claimed Sampling rate
Sharpening	Max SFR contrast value ≤1,05	Max SFR contrast value ≤1,1	Max SFR contrast value ≤1,2
MTF 50	≥0,5 × the minimum frequency required for MTF10	≥0,45 × the minimum frequency required for MTF10	≥0,45 × the minimum frequency required for MTF10

	Level A	Level B	Level C
Illumination non-uniformity for A3 and smaller	$\Delta L^* \leq 3$	$\Delta L^* \leq 3$	$\Delta L^* \leq 3$
Illumination non-uniformity for > A3 and ≤ A2	$\Delta L^* \leq 4$	$\Delta L^* \leq 5$	$\Delta L^* \leq 5$
Illumination non-uniformity for > A2 and ≤ A0	$\Delta L^* \leq 5$	$\Delta L^* \leq 6$	$\Delta L^* \leq 6$
Colour mis-registration	≤0,4 pixel	≤0,7 pixel	≤1 pixel
Distortion	≤1,5 %	≤2 %	≤5 %

millimetre and on the inside is the inch scale. The exact location and dimensions off the scale can be found in the Excel spec sheet. The millimetre scale starts at the left side of the horizontal scale and at the bottom of the vertical one. The inch scale starts at the right side of the chart and at the top. The white background of the scales is located behind the two scales so that the crossing of both scales at 30/30 mm is visible.

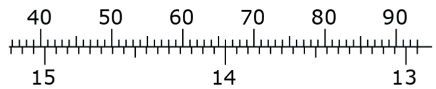

Figure C.7 — Example of scale

The scales are used to check deviation especially but not exclusively for pull through scanners and artefacts that affect the lines of a scale.

C.9 Grey scales

There are 4 grey scales, two horizontal ones and two vertical ones located half way between the border and the centre of the target. That means the vertical ones are vertically centred and located 105 mm left and right of the centre and the horizontal ones are horizontally centred and located 62,5 mm above and below the centre. The vertical version of the scale is 15 mm wide and each patch is 7 mm high. And the horizontal version is 90° tilted.

Each grey scale consists of 20 patches starting at L^* of 5 with 5 L^* value increments (5 to 95) and the last patch representing the max black of the target at a density level of app. 2,3 or above. Tolerances are given in C.3. The left vertical scale stats with L^* 95 at the bottom, the right one with L* 95 at the top. The upper horizontal scale has L^* 95 on the right and the lower on the left side. Exact locations are given in the Excel spec sheet. Patch numbers start at L^* 95 with 1. The numbers shall be printed on the inside of the scale in 8 pt Verdana and orange colour.

The grey levels shall be produced as gray tones without using a screening technology that may affect the noise measurement. In case a screening technology cannot be avoided the actual dot size needs to be 10 times smaller than the size per pixel expected be the camera or scanner. If this requirement cannot be met, noise and signal to noise ration cannot be measured. In this case the tonal values shall also be measured as an average value of a size big enough to cover at least 64 printing dots.

Figure C.8 — Example of grey scale

C.10 Colour patches

The colour patches are a similar to a subset of the x-rite colour checker SG. But with the production cost in mind the colour have been slightly modified. The first 18 colours are similar to the original colour checker and the last 9 colours are the highlight patches of columns D and K of the colour checker SG. In order to perform a detailed colour check the original x-rite colour checker SG or an IT8 target shall be used.

The colour patches with a size of 10 mm × 10 mm for each patch are aligned in 3 columns an 9 rows with the central patch B5 located at 150 mm/150 mm from the left bottom of the target are shown in Figure C.9. A copy of the set is rotated 180° and placed at the same distance from the target centre on its right side (E5 270/150). The exact locations can be found in the Excel spec sheet and tolerances for the colours are given in C.3. The targeted L^*, a^*, b^* values can be found in Table C.2.

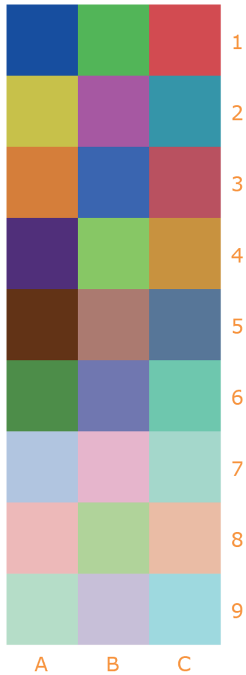

Figure C.9 — Example of colour patches

Table C.2 — Targeted *L, *a**, *b** values**

Colour patches	*L**	*a**	*b**
A1	18	24	−61
A2	82	3	90
A3	61	38	74
A4	21	35	−32
A5	32	24	32
A6	45	−32	38
A7	85	−2	−9
A8	86	13	7
A9	90	−17	6
B1	53	−45	38
B2	49	56	−14
B3	35	12	−53
B4	72	−25	65
B5	64	20	19
B6	53	8	−27
B7	85	13	0
B8	85	−11	26
B9	85	4	−6
C1	46	64	34
C2	48	−34	−31
C3	48	54	21
C4	71	19	80

Table C.2 *(continued)*

Colour patches	*L**	*a**	*b**
C5	47	−5	−25
C6	69	−35	−1
C7	86	−19	−1
C8	87	10	18
C9	85	−14	−9

The numbers shall be printed as shown on the bottom and the inside of the scale in 8 pt Verdana and orange colour.

C.11 Slanted edges

The slanted edge structures are designed for SFR (spatial frequency response) measurements used to determine sharpness and resolution of the imaging system. They shall be combined with the visual resolution ones into a box of 50 mm × 25 mm. The box located on the imagined centred horizontal line shall be rotated by 90° clockwise. Each slanted edge structure is arranged on an imagined 140 mm grid from the target centre. The slanted edge is located on the left side of the box with a rectangle of 25 mm × 25 mm and a grey level of *L** 63. Centred within that box is another box of 15 cm × 15 cm and a grey level of *L** 34 that is rotated by 5°. On the right side of the outer box there shall be another substrate white box of 25 mm × 25 mm that contains the visual structures described in 4.8. In the corners and the upper and lower centre of the 50 mm × 25 mm box there shall be crosses needed for the automatic detection. These crosses consist of 3 mm black lines with 0,38 mm thickness.

Figure C.10 — Example of slanted edges

The exact dimensions and locations can be found in the Excel spec sheet.

The manufacturer shall be responsible for the sharpness of the slanted edge. The edge shall be sufficient (and not be the bottle neck) to measure scanner resolutions of up to 600 pixels/in (~ 12 LP/mm) according to ISO 16067.

C.12 Visual resolution structures

The visual resolution structures shall be the ones specified in DIN 19051-2 target starting at 2,8 LP/mm up to 18 LP/mm. They shall be centred in the white box and rotated 45° clockwise (see image under 4.7).

The manufacturer shall be responsible for an appropriate resolution up to 18 LP/mm.

C.13 Additional chart border

Those who want to perform an additional more detailed colour check can mount an IT8 target inside of the additional chart border in centre of the ISO 19264 TEST CHART. By doing that the centre SFR structure, the colour patches of the ISO 19264 TEST CHART, and the background checkerboard will be covered and cannot be used.