TECHNICAL SPECIFICATION

ISO/TS 19264-1

First edition
2017-04

Corrected version
2018-05

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)

3.30
modulation
difference between the minimum and maximum signal levels divided by the sum of these levels

[SOURCE: ISO/IEC 29112:2012, 3.17]

3.31
noise
unwanted variations in the response of an imaging system

[SOURCE: ISO 15739:2013, 3.9]

3.32
opto-electronic conversion function
OECF
relationship between the log of the input levels and the corresponding digital output levels for an opto-electronic digital image capture system

Note 1 to entry: If the input log exposure points are very finely spaced and the output noise is small compared to the quantization interval, the OECF possibly has a step-like character. Such behaviour is an artefact of the quantization process and needs to be removed by using an appropriate smoothing algorithm or by fitting a smooth curve to the data.

[SOURCE: ISO 17321-1:2012, 3.3]

3.33
original-referred image state
scene-referred
image state associated with image data that represents the colour-space coordinates of the elements of a two dimensional hardcopy or softcopy image, typically produced by scanning artwork, photographic transparencies or prints, or photomechanical or other reproductions

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

Note 2 to entry: Original-referred image data are related to the colour-space coordinates of the original, typically measured according to ISO 13655, and do not include any additional veiling glare or other flare.

Note 3 to entry: The characteristics of original-referred image data that most generally distinguish them from scene-referred image data are that they refer to a two-dimensional surface, and the illumination incident on the two-dimensional surface is assumed to be uniform (or the image data corrected for any non-uniformity in the illumination).

Note 4 to entry: There are classes of originals that produce original-referred image data with different characteristics. Examples include various types of artwork, photographic prints, photographic transparencies, emissive displays, etc. When selecting a colour re-rendering algorithm, it is usually necessary to know the class of the original in order to determine the appropriate colour re-rendering to be applied. For example, a colourimetric intent is generally applied to artwork, while different perceptual algorithms are applied to produce photographic prints from transparencies, or newsprint reproductions from photographic prints. In some cases the assumed viewing conditions are also different between the original classes, such as between photographic prints and transparencies, and will usually be considered in well-designed systems.

Note 5 to entry: In a few cases, it can be desirable to introduce slight colourimetric errors in the production of original-referred image data, for example to make the gamut of the original more closely fit the colour space, or because of the way the image data were captured (such as a Status A densitometry-based scanner).

[SOURCE: ISO 22028-1:2016, 3.32, modified — A term has been slightly modified and second one added.]

3.53
test pattern
specified arrangement of spectral reflectance or transmittance characteristics used in measuring an imaging systems quality attribute

[SOURCE: ISO 12233:2017, 3.27]

3.54
tone
degree of lightness or darkness in any given area of an image

[SOURCE: ISO 12637-2:2008, 2.132]

3.55
vertical resolution
resolution value measured in the shorter image dimension, corresponding to the vertical direction for a "landscape" image orientation, typically using a horizontally oriented test chart feature

[SOURCE: ISO 12233:2017, 3.28]

3.56
white balance
adjustment of electronic still picture colour channel gains or image processing so that radiation with relative spectral power distribution equal to that of the scene illumination source is rendered as a visual neutral

[SOURCE: ISO 14524:2009, 3.16]

4 System setup and calibration

4.1 General

The image capture system needs to be carefully set up to ensure consistent, repeatable, and high quality results. Prior to checking or confirming the quality of the system, it always needs to be accurately calibrated and adjusted. For a more detailed description on how to set up and calibrate an imaging system prior to imaging systems quality analysis see ISO/TR 19263.

4.2 System configuration

The camera needs to be mounted on a solid stand that does not move during exposure. Any ambient light that does not originate from the desired illumination shall be avoided.

4.3 Camera/scanner settings

The lowest sensitivity and lowest image compression rate, i.e. the highest image quality, should be selected.

4.4 Exposure

The exposure shall be adjusted so a diffuse white flat surface (a test chart may be used for this) is captured and recorded using encoding values that have an L^* value equal to the actual L^* value of the diffuse white flat surface. In the case of a three-dimensional original the placement and orientation of the diffuse white flat surface are left to the photographer, but should result in a reasonable image appearance (when displayed accurately) compared to viewing the original. The user needs to make sure that the dark areas are also not clipped. If clipping in the black areas is encountered, the user needs to ensure that the system is able to capture the dynamic range of the original referring to the measurement described in ISO 21550.

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.

In order to decide whether or not the quality of the system is sufficient for the intended application a set of aims and tolerances is required. Annex B describes three tolerance levels A, B and C, which can be used or combined into a customized list for aims and tolerances for a specific project or application.

6 Imaging systems quality characteristics and metrics

6.1 General

The following tables describe the image characteristics that should be used to analyse the quality of a digital image. Each table provides a description of the image characteristic, references the related standards used to measure the characteristic, states a summary of the measuring method, and a specification of which technical patterns of the reference target should be used for the measurement. The tables also include aim values for optimal imaging systems quality. Annex B contains aims and tolerances for producing accurate and acceptable digital reproductions.

The image characteristics are grouped according to the basic metric they relate to: Tones and Noise (tone reproduction, gain modulation, dynamic range, noise, banding, defect pixels), Colour (white balance, colour reproduction), Details (sampling rate, resolution, sharpening, acutance), and Geometry (illumination non-uniformity, colour mis-registration, distortion, reproduction scale).

Even though this document details a specific multi-pattern chart, these values can also be measured using the charts outlined in the different standards, e.g. in ISO 12233, or other charts that fulfil the requirements described in the standards.

6.2 Tones and noise

Characteristic	**Tone reproduction**
Description	The opto-electronic conversion function (OECF) describes the relationship between the input light levels and the corresponding digital output levels for an opto-electronic digital image capture system. To produce an accurate reproduction it is important that this curve is shaped in a way that the luminance (CIE L^*) levels of the original are transferred into digital values that represent the same L^* values in the selected colour encoding of the image.
Related standards	ISO 14524 (cameras) ISO 21550 (scanners)
Measurement	Tone reproduction/response curve (TRC) Measurement in L^* values and tolerances for L^* differences between original and captured image
Reference target	Grey scale (spectrally neutral) in a test chart as defined in Annex A that is ideally equally spaced in L^* values.
Aim	The smaller the deviation between the L^* of the patches in the reference target and the L^* values represented by the digital code values the more accurate the tone reproduction. Correct tonal capture is expected from L^* 95 to ≈ L^* 5
Notes	Also known as tone response.

Characteristic	**Defect pixels**
Description	Pixel or subpixel that operates in a way other than the one in which it is driven. (ISO 9241-302)
Related standards	ISO 9241-302
Measurement	Due to the different characteristics of defect pixels the measurement needs to be performed on a black image, a grey image, and a white image. For the black image the sensor does not get exposed to light during the image capture. This can be done by closing the lens cap or for scanners by switching off the light. For the grey and the white image the sensor needs to uniformly be exposed to light so that the digital output level reaches a value close to the centre value of the digital output value range (e.g. 127 for an 8 bit image) for grey and close to the maximum output level for white. A range around the typical noise values needs to be defined for those pixels that are ok and all other pixels outside the range (outliers) are then specified as defect.
Reference target	Uniform light source or target like an integrating sphere or a uniformly illuminated white target.
Aim	Identification of single pixels or clusters that do not represent the original respectively are out of the expected value range. The smaller the amount of these pixels the better.
Notes	This may not be required for every imaging system‘s quality check because it is mostly taken care of by the manufacturer of the capture device. Only if pixels occur that show problems this may be evaluated. Determining defect pixels is not part of the required measurements for imaging systems quality analysis.

6.3 Colour

Characteristic	**White balance**
Description	Adjustment of electronic still picture colour channel gains or image processing so that radiation with relative spectral power distribution equal to that of the scene illumination source is rendered as visually neutral (see ISO 14524). This ensures that neutral greys in the original are visually neutral in the image.
Related standards	ISO 14524
Measurement	Calculated from tone reproduction/response curve (TRC) with values in $L^*a^*b^*$. $$WB = \max_{1 \le i \le n}\left[\sqrt{\left(a_i^2 + b_i^2\right)} - \sqrt{\left(a_{i,\mathrm{ref}}^2 + b_{i,\mathrm{ref}}^2\right)}\right]$$ The image needs to be converted from RGB to $L^*a^*b^*$ using the colour encoding description of the colour encoding the image is in (like sRGB, Adobe RGB, …).
Reference target	Grey scale patches in the target defined in Annex A.
Aim	The smaller the white balance the more accurate the reproduction. Tolerances to be defined in ΔC^*.
Notes	The CIE C^* approach has been selected over an RGB approach because CIE C^* better describes the visibility of colour casts.

— Used image processing software (Name and version)

— Camera settings that impact the imaging quality

  — Including aperture, shutter speed, ISO (sensitivity/speed)

— Important image data

  — including image width and image height, claimed sampling rate, bits per sample (bit depth), colour encoding, colour profile

7.2 Example report for tone reproduction results

Based on the tolerance range for the individual application, the L^* values extracted from the image of the test chart shall be reported against the L^* values of the original. In case the results are presented as a table the differences between the original and the image shall be stated in a third column and the minimum and maximum differences at the bottom of the table show if the values are within or out of the tolerances. Another option for using the max and min values is the coloured indication of values that are out of the defined tolerances, see Table 1.

Table 1 — Max and min values need to be in the given range based on the tolerances for the specific application

Original L^*	Camera/ Scanner L^*	ΔL^*
95	96	−1
90	88	2
85	85	0
80	79	1
75	75	0
70	69	1
65	66	−1
60	59	1
55	54	1
50	50	0
45	44	1
40	39	1
35	35	0
30	29	1
25	23	2
20	19	1
15	14	1
10	9	1
5	6	−1
	max	2
	min	−1

In case of the presentation in a graph the tolerances shall clearly be indicated by separate lines or marking the area of values within tolerance.

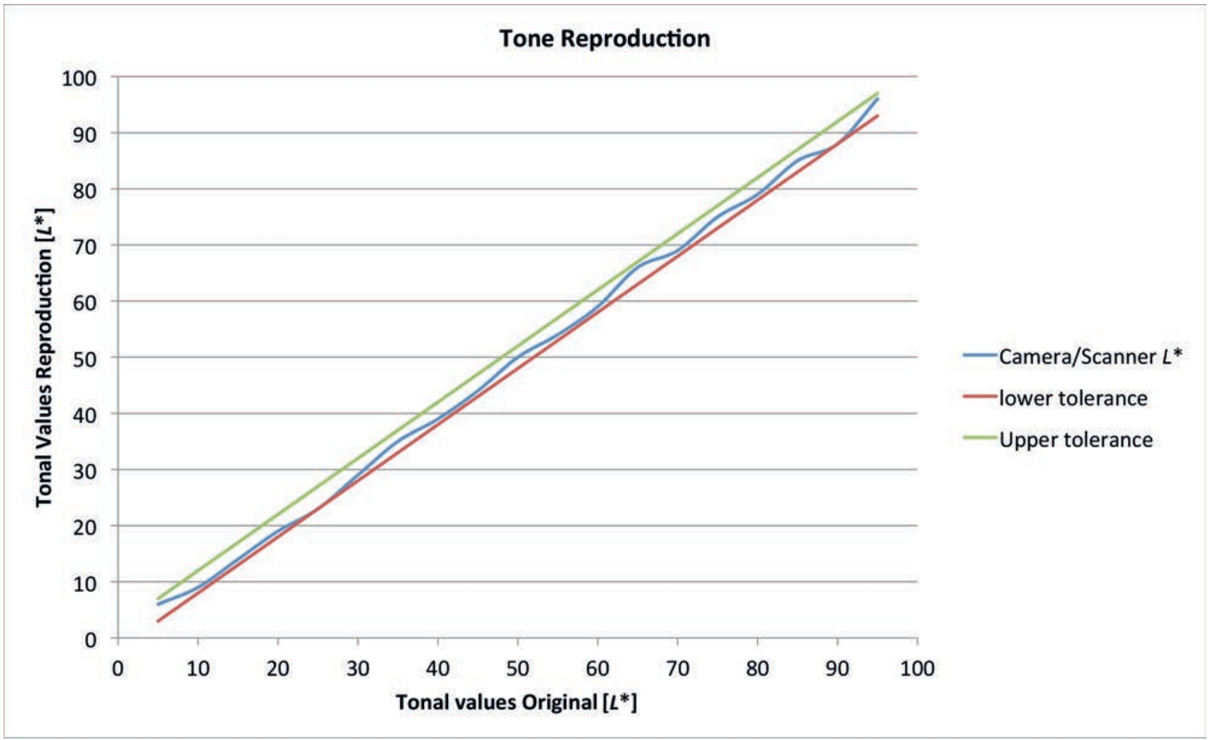

Figure 2 — Graphical representation for the tone reproduction

7.3 Gain modulation

Table 2 with the results for gain modulation shall contain either the pair of the patches for which the gain modulation was calculated or the average L^* value of the two compared patches in the first column and the calculated gain modulation in the second column.

Table 2 — Gain modulation
(max and min values need to be in the specified tolerance level)

Patch	Gain Modulation
1/3	1,1
2/4	1
3/5	1
4/6	0,9
5/7	1
6/8	1,2
7/9	0,9
8/10	1
9/11	1,1
10/12	0,9
11/13	1
12/14	1,2
13/15	1
14/16	0,9
15/17	1

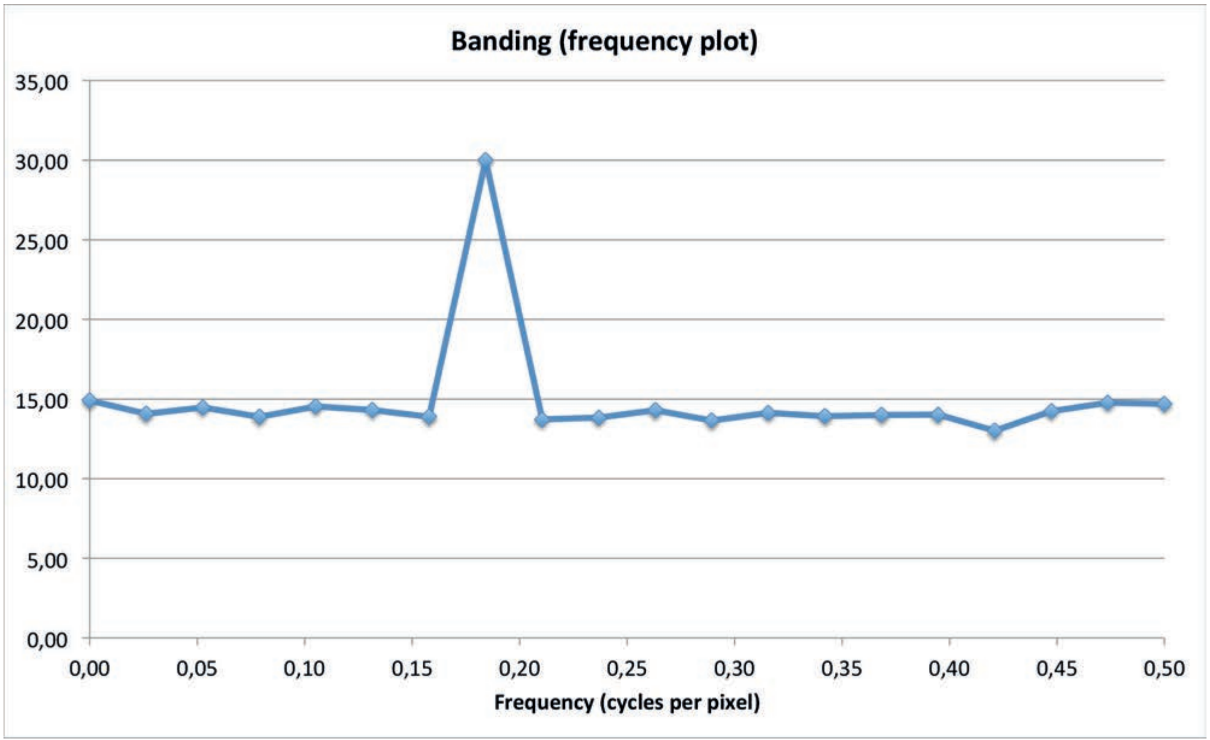

Figure 6 — Frequency peak in the Fourier transform of the pixel values representation
(one or multiple peaks indicate the presence of banding)

7.7 Defect pixels

For the evaluated area the number of pixels outside of the expected range are reported. In case of the intention to correct them, a pixel map/table with the x, y coordinates of the defect pixels can be reported.

7.8 White balance

Table 4 — White balance over the L^* values
(the tolerance level is specified for the max of the absolute ΔC^*)

Original L^*	White balance C^*
95	0,00
90	1,00
85	1,34
80	1,91
75	1,44
70	0,30
65	−0,20
60	−0,32
55	−0,15
50	0,67
45	0,72
40	1,05

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

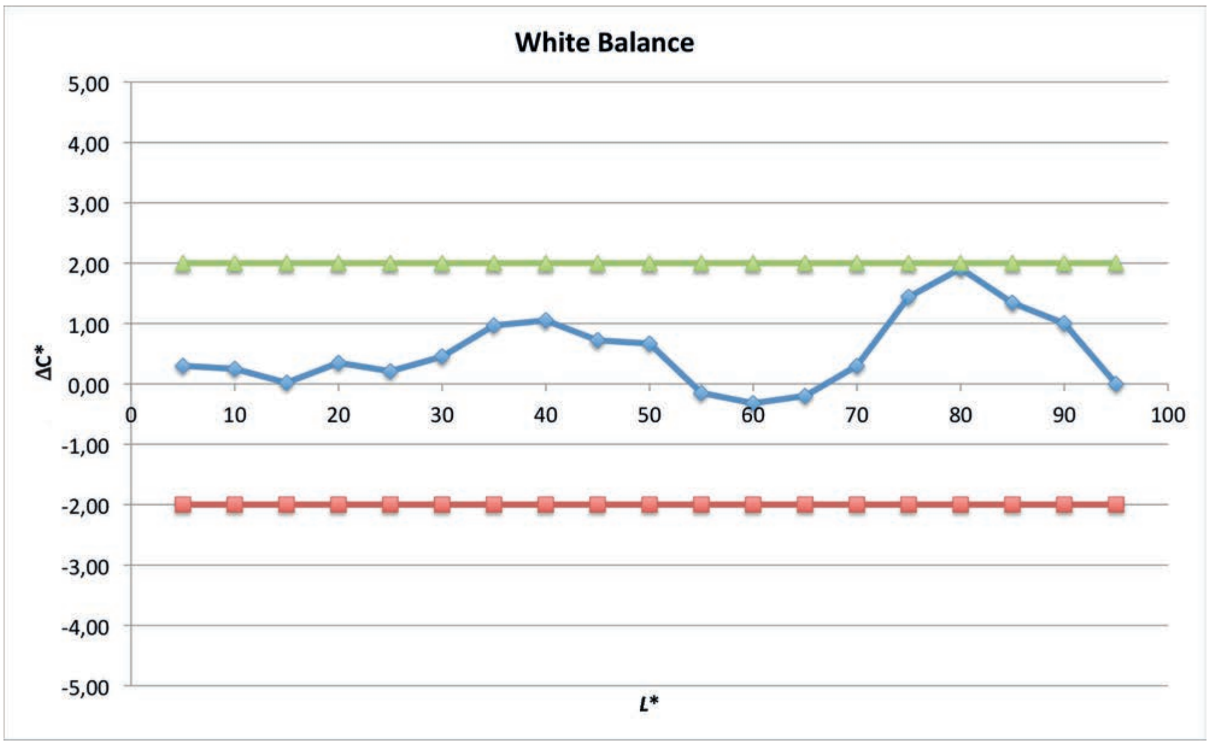

Figure 7 — Graphical representation of the white balance over the L^* value with the upper and lower tolerance levels

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