TECHNICAL REPORT

ISO/TR 19263-1

First edition
2017-03

Photography — Archiving systems —

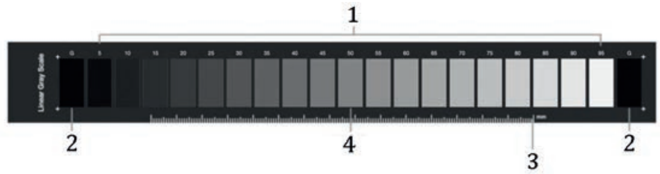
Part 1: Best practices for digital image capture of cultural heritage material

Photographie — Systèmes d'archivage —

Partie 1: Meilleures pratiques pour la capture d'images numériques du matériel de patrimoine culturel

Reference number
ISO/TR 19263-1:2017(E)

2.6 Linear grayscale



Key

1 semi gloss values (5*L** to 95**L*)

2 gloss black (4*L**)

3 measurement scale, in mm

4 perceptual middle value (50*L**)

Figure 6 — Example of linear grayscale

A linear grayscale is useful for configuration and verification of tone reproduction (OECF) and gain modulation. The target incorporates semi-gloss spectrally neutral pigments equally spaced in 5*L** steps from *L**5 to *L**95 with additional gloss black patches. The gloss patches extend the dynamic range and are used to visually assess lighting reflections and glare from improper lighting geometry.

2.6.1 DCSG colour chart

Figure 7 — Example of DCSG colour chart

The X Rite Colour Checker® Digital SG (DCSG) colour chart is useful for colour calibration (device characterization). Colour charts may vary in terms of substrate, gloss factor, colour gamut and number of patches. A colour chart that closely matches the surface quality and colour gamut of the original artwork may be utilized.

2.6.2 Limitations of Chart Based Imaging System Analysis

Being that ISO 19264 is based upon analysis of test charts with technical patterns and reference values there are inherent limitations that need to be considered. Fabrication of technical targets varies over time, and targets have a finite life span. Baseline data used to define technical targets (chart reference data) can also vary between users and vendors. Vendors may improperly implement the analysis methods outlined in ISO 19264. Beyond these possible variables, there are variables in the surface qualities of original artworks, capture illuminants and sensors that limit the ability to ensure an exact colourimetric or perceptual match.

spatial pattern of repeated, e.g. red, green and blue, signals. At this point these raw data constitute the first form of 'raw' recorded image, the raw corrected CFA data.

The next step in a typical processing path is the generation of a fully populated three-colour image array. Propriety algorithms, aimed at minimizing colour artefacts, can be applied here. This de-mosaicing operation is the interpolation of the single-record array to a 'raw' interpolated red, green and blue data set. While de-mosaicing algorithms have improved over time, reproduction of certain originals with halftones, etchings and other materials with high frequency visual patterns can suffer from colour Moire artefacts. Moire is defined as a spatial beat phenomenon generated by the modulation of numerous spatial frequencies. Moire artefacts can impact both luminance and chrominance. Line scanners, and multi-shot sensor systems minimize the occurrence of colour Moire artefacts as de-mosaicing is not necessary in these imaging systems.

White-balance, and matrix colour-correction operations are usually applied next. The result is an image data set that is in a scene-referred colour encoding.

The final step in the image processing chain is the rendering, usually for display. The result is a finished image data array in an output-referred colour encoding. This step may be a simple colour-space transformation, but can also include choices for gamut mapping and colour preference.

While the above steps are common in colour image acquisition systems, specific implementation details will vary. Understanding the signal (colour) encoding of a raw image is as important as agreement on a particular file format.

4.2 Scene referred and output referred image states

The terms scene referred and output referred are essential to understand best practice for artwork digitization. ISO 19264-1 employs objective methods to help create images that refer to the original scene or object, in other words: a scene referred image. While scanners are typically engineered to provide a scene-referred response, the majority of commercially available imaging systems are engineered to deliver finished output referred images optimized for "pleasing" renditions. Unfortunately each manufacturer and observer may have different subjective opinions about what is pleasing as opposed to what is accurate. A scene-referred image can be repurposed and reformatted to any media as it contains information traceable back to the original object. When a scene-referred image is converted (via ICC or other colour conversion) or visually edited and optimized for reproduction to a specific medium or device, it becomes output-referred.

4.3 User controls and readouts

4.3.1 General

Digital imaging systems (cameras or scanners) and related control software should provide users necessary access to controls relevant to ISO 19264-1 system optimization. If an imaging system limits access to critical controls and only offers output referred or "factory" image processing functionality, image quality may suffer and users may be unable to configure systems to meet defined quality criteria. If an imaging system does not offer appropriate user controls and readouts the application of ISO 19264-1 may be limited to imaging system performance evaluation and imaging system performance monitoring only, see ISO/TR 17321-3.

4.3.2 Colour Processing Controls

The aim of the colour processing for ISO 19264-1 is to produce accurate scene colourimetry, with the scene adopted white chromatically adapted to the chromaticity of the image encoding adopted white. ISO 17321-1 specifies camera characterization metrology. ISO/TR 17321-2 provides considerations for determining scene analysis transforms. Cameras and scanners should fully support custom user characterization methods such as ICC colour profiles (ISO 15076-1), or DNG digital negative profiles (DCP). Users should be able to select any valid working colour space, destination colour space, custom generated input colour profiles and should be able to disable any factory or proprietary colour rendering functions (untagged). Colour encoding should be of sufficient gamut to encompass the gamut of the original.

4.3.3 Exposure readouts

The display of scene-referred image values converted to CIE $L^*a^*b^*$ values in the imaging system histogram is preferred. If an imaging system is not able to display scene referred $L^*a^*b^*$ values, RGB values are acceptable as long as they are clearly defined i.e. source or output encoding, see ISO/TR 17321-3.

4.3.4 Raw processor readouts and controls

If raw image processing software is part of the imaging workflow, the software should be able to read/display scene referred data and have the ability to disable output rendering and should also honor recorded scene adopted white chromaticity (see 4.3.2), User readouts and representation of exposure should operate as described in 4.3.3, see also ISO/TR 17321-3.

4.3.5 Other user controls

The ability for users to create, modify or disable image enhancement functions is helpful when using ISO 19264-1 for imaging system performance optimization. User access to generate custom flat-field corrections and lens corrections can help improve uniformity and minimize geometric distortion when using DSC systems. For scanners and turnkey systems these corrections may not be necessary. Image sharpening and other enhancements require careful attention and are generally discouraged. If and when modifications are made to user controls, for imaging system performance optimization, adjustments need to be documented.

4.3.6 Unwanted data modification

Imaging systems increasingly rely on proprietary image enhancement technologies. In some cases these enhancements can improve ISO 19264-1 results. For example: a DCS or Scanner may employ preset corrections for uniformity (vignetting correction) or geometric distortion, however other enhancements can cause problems. Variable or local image processing enhancements such as near neutral colour optimization, local or single colour improvements or local contrast optimization functions must be avoided. Ideally imaging systems that employ these enhancements should allow the user to disable the functions.

4.4 Master images and derivatives

4.4.1 General

Once an imaging system has been configured to meet the quality criteria as outlined in ISO 19264-1 the resulting images are typically saved as 8 bit or 16 bit RGB Tiff files. Tiff files should include either an embedded device ICC profile, or should be rendered to a standard RGB encoding space with sufficient colour gamut to contain the colour gamut of the originals being digitized. While not a part of ISO 19262 terminology, it is common to refer to these images as master image files.

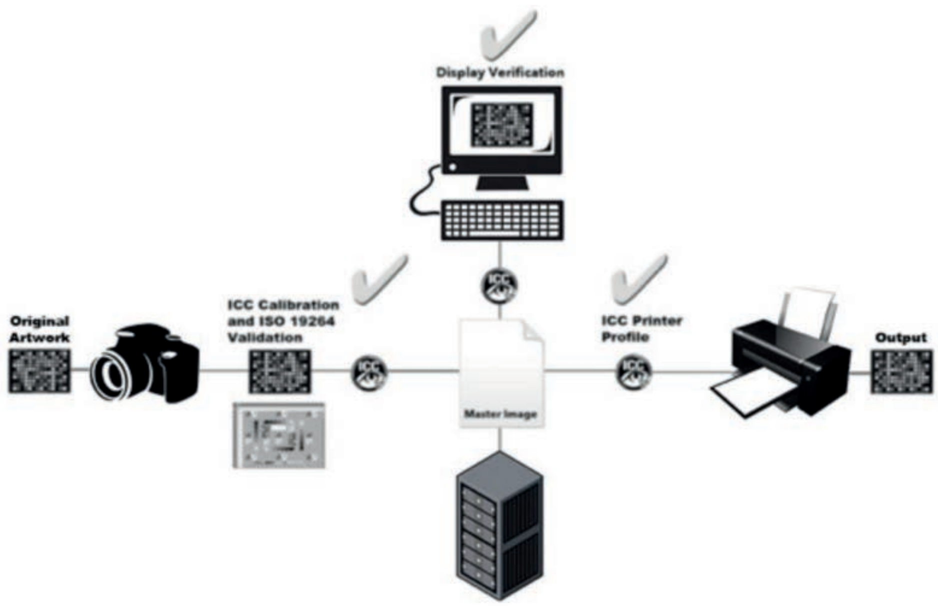
Any number of derivatives may be created from the master image. A common derivative would be a rendition that is typically down sampled, converted to an appropriate output referred colour encoding space (sRGB) in a JPEG compressed file format. Another derivative may be a set of thumbnail or preview images for a DAM, CMS or other information system. It is important to note that in order to display correctly, careful attention should be given to the proper use of embedded ICC colour profiles and colour management configuration through the entire workflow including web browsers and mobile devices.

4.4.2 Raw image files

A raw image file is often the starting point in the imaging process, and is typically the source for rendition to an image master Tiff image that can be analysed using ISO 19264-1. Raw image data and raw processing software tools are not standardized; therefore results can be highly variable. For example: the same raw image data and accompanying adjustments processed through one raw processor will not necessarily match when processed through another raw processor. Due to the variability of raw data formats and processing software raw images are outside the scope of this document and ISO 19264-1.

4.4.3 Artwork reproduction cycle

Creating a scene referred digital master image file is the first step in the larger reproduction cycle. Best practice in artwork reproduction relies on a fully colour managed workflow where each device is characterized via an ICC colour profile. While the scope of this document is limited to the creation of well-formed scene referred digital master images, it is useful to visualize where these images fit into the larger context. The diagram in Figure 9 illustrates a typical colour managed reproduction workflow. ISO 19264-1 applies only to the highlighted area.



NOTE An excellent reference is the benchmarking art interchange cycles final report

Figure 9 — Typical colour managed reproduction workflow

Creating and archiving scene-referred masters does not guarantee that the data will automatically translate to a faithful visual match upon display or hardcopy output. A number of factors including limitations of current technology, accuracy of charts, reliability of reference data and differences in observers and light sources (Metameric) factor into the reproduction workflow. The phenomenon whereby originals with different spectral reflection features provide different colour accuracy is called Metamerism. An imaging system configured using an ICC colour correction profile based upon a specific colour target such as the Digital ColourChecker SG can result in very low delta E values however, this does not necessarily communicate the specific colour accuracy of the originals with spectral reflection qualities other than the Digital ColourChecker SG. See also ISO 19262:2015, 3.160.

It is important to note that a scene-referred image is not expected to result in an exact facsimile of an original, but rather a digital master that can serve as a consistent, predictable source for future conversion/optimization. From this source image asset any number of optimized derivatives can be generated (manually or automatically) to satisfy reproduction via current and future output technologies. Understanding the variables in play, from the auditing of material to be digitized to the selection and configuration of appropriate equipment, is critical to success. The use of ICC colour management across the entire workflow is essential for successful image reproduction.

5.4 Establish exposure

Establishing exposure for DSC systems is difficult to summarize due to a current lack of standardization of UI value readouts however the following generalized steps based upon the use of grayscale targets and tolerances have proven to be reliable.

— Configure DSC or host control software to disable tone reproduction curve adjustments if possible. Note: some systems offer a “linear” or “reproduction” tone curve setting.

— Disable camera/host colour processing (to the extent possible).

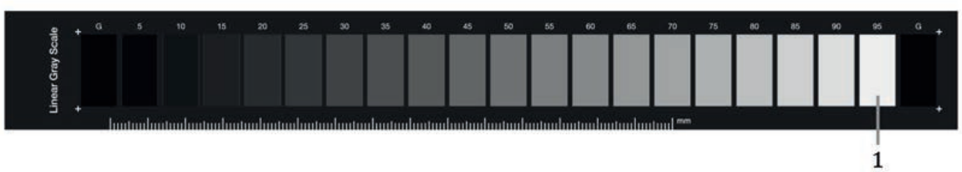
— (RIMM RGB). If RIMM RGB or suitable scene referred encoding is not an available option, the default colour encoding should be at large enough colour gamut to encompass the colour chart utilized for profile creation.

— Make sure that all image adjustments are set to default or null.

— Disable any automatic gain (analog or digital) or adaptive tone reproduction.

— The procedure for ensuring achromatic whites, grays, and blacks (white balancing) should be fixed using a known spectrally neutral chart value. The chart value for neutralization should be between *L**50 and *L**95.

— Place a linear grayscale (or any target with an *L**95 spectrally neutral patch) in the centre of the image area and make a test exposure. Adjust the system exposure (via adjustment of light output, distance and or camera settings) until a value of *L**95 is achieved (see Annex A for RGB values if the system does not support *L** readouts).



Key

1 95*L**

Figure 10 — Linear gray scale for establishing exposure

5.5 Establish tone reproduction curve (OECF)

— Using the linear grayscale verify the remaining values along the gray scale are within tolerance(s) Note: if tolerances for darker values do not match aims, it may be necessary to adjust lighting angle and or tone curve/histogram controls in host control software. If adjustments are necessary, these adjustments should be saved as a user preset

— All user settings should be recorded

5.6 Create an ICC colour profile

ICC Colour profiles can be created using integrated camera profiling functions or external third-party profiling applications. The X Rite ColourChecker® Digital SG (DCSG) colour chart is often along with appropriate chart reference data are often used for this purpose.

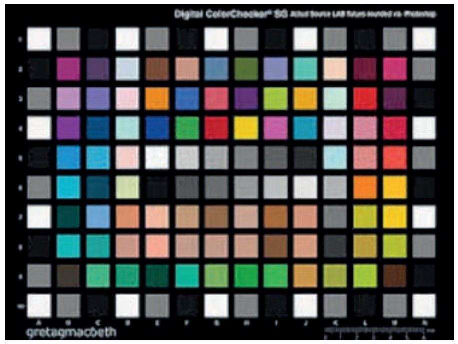


Figure 11 — ICC colour profile

— After having established correct chart illumination and exposure, capture the colour chart. If your software does not support built in ICC colour profiling export the file as a 16bit RGB Tiff in a colour encoding space that is larger gamut than the colour chart you wish to utilize for profiling (Note it is possible to characterize cameras using raw image data, but the process can become complicated due to a lack of standardization for raw data and its interpretation).

— Using any software capable of creating ICC input profiles, follow the manufacturer's steps to generate an ICC profile.

— After loading the ICC input profile, select the profile in the DSC or host control software.

— Re-Verify Neutral Balance, Exposure, and Tone Reproduction (OECF).

— Capture a new chart image and re-check neutral balance, exposure, and tone reproduction. Export the file making sure to embed the custom ICC device profile or working colour encoding space.

5.7 Analyse colour and tone

The image of the colour chart can be compared to the chart reference data manually or via open source or commercial analysis tools. For colour evaluation the ΔE 2000 formula is recommended using a SL 1 in the calculations*. The ΔE 2000 colour difference formula as published was not specifically engineered for scene referred imaging analysis and assumes a non linear transform for lightness that is not appropriate for calculating ΔE values for scene referred imaging applications. Specifically, without modification, the ΔE calculation will report inaccurate ΔE values even when source L^* target values perfectly match L^* values in an image. Ensure that the software you are utilizing for image analysis supports this particular ΔE calculation method.

When configuring an imaging system it is a good idea to validate the capture of a colour chart to its reference data as well as comparing spectral measurements of sample artworks with their representations. It's essential that the chart and reference data are verified or known.

6 Application of image quality analysis

6.1 Selection of imaging systems: preflighting equipment or vendors

The best time to implement an imaging strategy is after your project scope has been clearly defined and the collection has been assessed. If the collection goals are appropriate and the size of original work is known, one can evaluate equipment strictly based upon technical performance criteria and by analysing test targets. Due to the complexity of imaging systems it is common for imaging systems to easily pass certain criteria while failing other criteria, the results of ISO 19264 analyses will help identify and resolve problems. For example: A failure to pass illumination uniformity aims can be traced to the incorrect positioning of a light source. Failure in a single chart MTF region may reveal that the imaging system plane is not parallel to the artwork plane. If an imaging system does not pass certain

