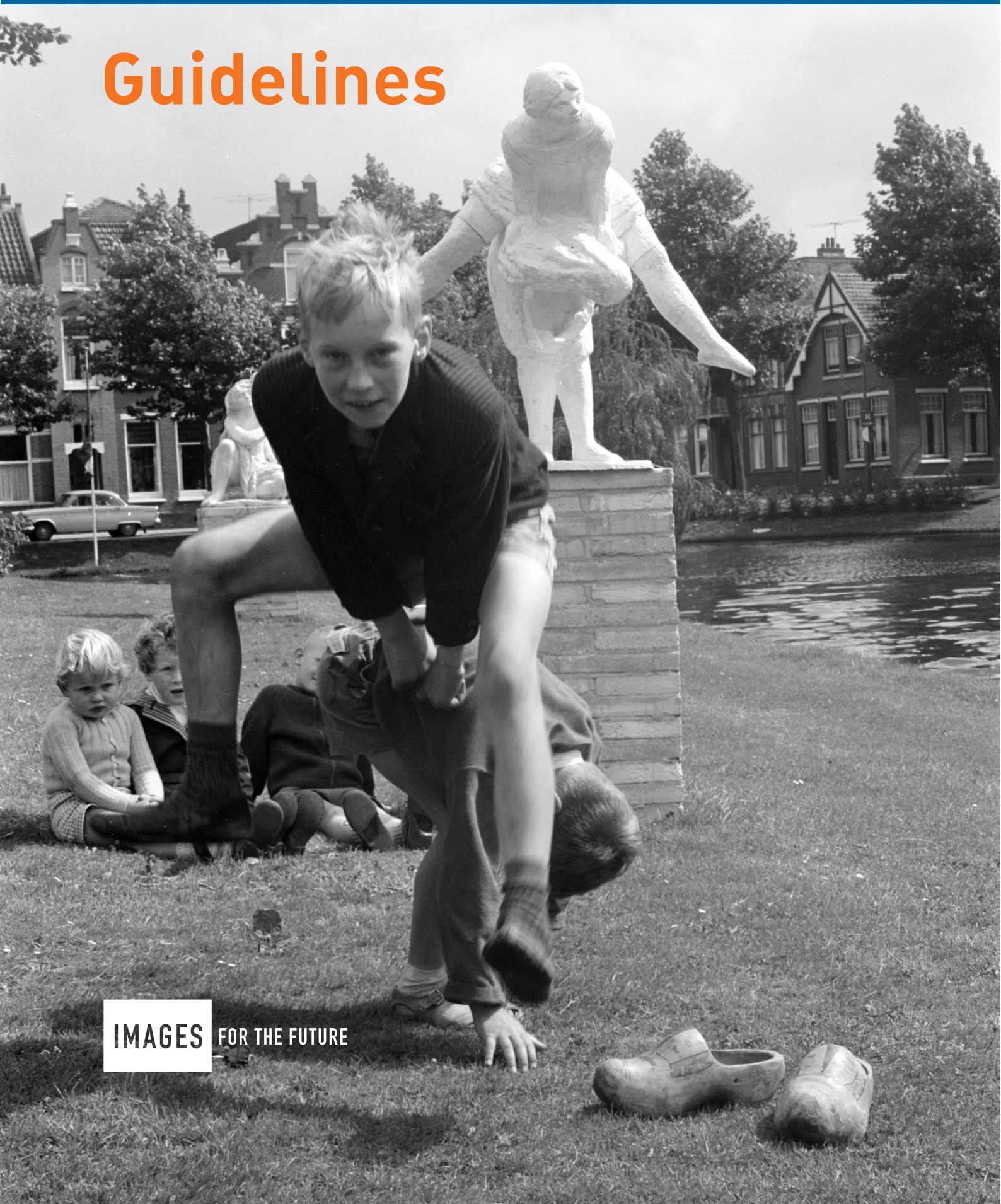


Digitisation of photographic materials

Guidelines



IMAGES FOR THE FUTURE

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Preface

The comprehensive document you are looking at was realized as part of the project Images for the Future (Beelden voor de Toekomst). The document is a manual for digitisation of photographic materials and it is aimed at (technical) professionals.

The manual offered in this document not only serves to realize putting the large-scale digitisation of photographs and negatives of the consortium Beelden voor de Toekomst (Images for the Future) out to tender at European level, but also to regulate the process.

Images for the Future is one of the world's largest digitisation programmes in the field of cultural heritage, and within this the Nationaal Archief of the Netherlands is leading in the preservation, digitisation, enrichment and online presentation of photographic materials.

With this digital publication the Nationaal Archief of the Netherlands wishes to establish and share the knowledge it has developed in this field with colleagues. We hope it will be useful to you. We assume that this document provides the basis for various initiatives regarding the preservation of cultural heritage.

Martin Berendse, National Archivist

1 Introduction

The Dutch program Images for the Future (Beelden voor de Toekomst) started in 2007. A special budget of € 154 million was made available by the government over a period of 7 years to safeguard the Netherlands' endangered photographic and audiovisual heritage. In total, 137,200 hours of video, 22,510 hours of film, 123,900 hours of audio and 2.9 million photographs in the collections of the Netherlands institute for Sound and Vision, EYE Film Institute Netherlands (formerly known as Foundation Netherlands Filmmuseum) en the Nationaal Archief (the Nationaal Archief of the Netherlands) are to be restored, conserved, digitised and made accessible to the public.

As part of the European tender procedure for the digitisation of photographic materials, the consortium partners compiled a descriptive document. The Nationaal Archief has many years of experience in high-quality microfilming and in the digital transfer of archive materials, which has proven invaluable in formulating these guidelines and for creating the technical specifications used in the tender document.

The guidelines drawn up by the Nationaal Archief correspond mainly with those compiled for preservation scanning in the Dutch national program Metamorfoze, which focuses on the preservation of paper heritage. The most important difference is the fact that the Nationaal Archief guidelines are specifically suited to the digitisation of photographs and negatives. For example, the process of converting a negative into a positive image is defined in considerable detail. In addition, the reference charts with known characteristics (so called 'test targets') are suitable for different photographic formats. Resolutions are set in accordance with the original image's format. For practical reasons, the OECF parameters have been relaxed and test targets are not provided for each individual digital image. Last but not least, the Nationaal Archief has adopted a meaningful file naming system. The consortium partners created special software to enable the checking of test scans by both the digitisation contractor and the principal.

The guidelines presented in this publication are an abridged version of the full technical specifications included in the tender document. They summarise the most essential components of the digitisation process for photographic materials. To help assess the tenders submitted, a more extensive set of criteria has been compiled. Also a number of questions have been formulated in order to evaluate the tenderer's know-how and quality. For the sake of clarity those chapters have been omitted from this document.

Chapters 2 through 4 describe the process for the digitisation of photographs and negatives. The guidelines in chapter 2 cover both formats in general, whilst chapters 3 specifically addresses photographs and chapter 4 negatives. The final chapter provides a brief insight into the present situation. The digitisation project has been running for half a year and with this experience in mind, and also in view of recent technical developments, the Nationaal Archief proposes to make some changes to the guidelines.

2 Digitisation of photographic materials

2.1 Workflow

The expected workflow is as follows. One lot includes several collections. The Contracting Authority offers one or – in the case of small collections – several collections on each occasion. In the case of a large collection, the Contracting Authority splits it into two or three parts. In this way various full or part projects for each lot are created .

For each of these, agreements are reached regarding the planning and duration of its digitisation. The Contracting Authority supplies exact specifications for that process, which fall within the general frameworks defined in the Descriptive Document. The Contractor draws up a final report on each full or part project. A work order form is used for this purpose.

The collection remains with the Contractor until the corresponding full or part project is approved by the Contracting Authority. This is so that the Contractor is still able to correct any mistakes. Once the digital files have been approved, the source material is returned and then checked for completeness and possible damage.

Arrangements may be made concerning the partial delivery of larger part projects.

2.2 Original objects

Handling photographic materials

The workplace must be kept clean and tidy. It is not permitted to eat, drink or smoke in the workplace and, as far as possible, it must be kept free of dust. The workplace must offer sufficient space for source materials and packaging. Damage caused by wearing jewellery or loose clothing must be prevented. It is only permitted to handle the source material with suitable clean gloves. Sharp objects are prohibited in the workplace and it is only permitted to write in pencil in the vicinity of the source materials.

If it is necessary to remove dust from source material, a safe method must be used. This must leave no traces (eg. oil) on the original object (as occurs when using compressed air without air-oil separators). The source material must not be scratched (as caused by using brushes). The contractor must not use any solvents or wet methods to remove dirt or dust. The use of aerosols with air is prohibited, unless it can be proven that these are suitable for the job.

Preparing for digitisation

The Contracting Authority ensures that the source materials can be handled easily. Lists with series of inventory and/or box numbers are provided for each full or part project. If anything is unclear, it is essential that the Contracting Authority be contacted immediately.

If possible, the Contracting Authority provides the source material sorted according to the resolution to be used for its digitisation. The Contractor can then work as much as possible with the same hardware and software settings.

With each full or part project, the Contracting Authority provides one or, if necessary, several work order forms containing information relevant for the digitisation process – for example, the type of material, file names, required resolution, series of inventory numbers, series of photograph numbers, relevant numbering and bit depth.

Completeness

Most of the source materials to be digitised have a unique number. With series of objects, it is possible that there are gaps in the numbering. The objects are not necessarily in numerical order. If the Contractor encounters the same number twice within a collection, it is essential that the Contracting Authority be contacted immediately.

If objects have no number, as is often the case with photo albums, then the scan sequence determines the photograph or album page number. The Contracting Authority will provide instructions in this respect.

If the Contractor encounters any object without a number and has received no relevant instructions, it is essential that the Contracting Authority be contacted immediately.

Sequence

Source material with a unique number may be digitised in a sequence preferred by the Contractor (eg. sorted by format), as long as the original physical order and completeness are guaranteed. The physical order of source material without a unique number must not be changed. If possible, the Contracting Authority supplies objects sorted by format; the relevant details are provided on the work order form for each full or part project.

Irregularities

The Contracting Authority identifies any anomalies or peculiarities relevant to the job in hand and notifies the Contractor of them. The two parties then go through these irregularities together.

If the Contractor detects irregularities of which it has not been notified, the Contracting Authority must be contacted as soon as possible. Agreements must be set out in writing.

2.3 Software and settings

Recommendations for monitor settings

Monitor settings are of great importance for the visual assessment of images, in particular where this involves the gamma and contrast curve adjustment of negatives. The following recommendations are closely related to the circumstances in the working area.

Recommended general monitor settings are:

- white point 6500 K;
- gamma 2.2;
- luminance at least 80 cd/m²;
- grey background screen and, as far as possible, removal of colours from the user interface.

Alongside these basic settings, the monitor must be calibrated regularly and a monitor profile must be created. The most reliable method of creating such a profile is to use a colorimeter or spectrophotometer with the associated software. The best results are obtained using high-end monitors made by, for example, EIZO, LaCie and NEC.

Recommendations for the design of the image-processing area

The design and lighting of the work area help to determine the accuracy with which one can assess images. It is recommended that the scanning area and the area where negatives are digitally processed comply with either ISO 3664 or the newer ISO 12646. The purpose of applying these standards is to remove disruptive effects from subjective visual assessments of images as far as possible, and to promote uniformity in the assessments made by the Contractor and the Contracting Authority.

The following recommendations are derived from the above standards.

- The ambient lighting must be less than 64 lux and preferably less than 32 lux.
- The colour temperature of the ambient lighting must be 5000 K.
- The work area must be painted, decorated and furnished in neutral colours, preferably grey.
- Ideally, the walls, floors and furnishings should be grey and free of posters, images and other objects that could influence the observer's view.
- All sources of glare must be prevented.
- Lamps must be shaded or dimmed in such a way that they do not reflect onto the work surface or screen. A hood around the monitor is recommended.
- Daylight should be excluded, as its colour temperature and intensity vary.

2.4 Digitisation

Type of camera or scanner

Equipment for digital imaging is still being developed, and not all of it is suitable for high-quality imaging. The Contractor is responsible for selecting hardware and software that comply with the specifications contained in the Descriptive Document.

Orientation

The digital image must be oriented in such a way that it is presented horizontally (portrait or landscape), regardless of whether this results in any text being at the wrong angle. In the case of deviating source material, such as photograph albums, the Contracting Authority will state the required orientation.

Header information

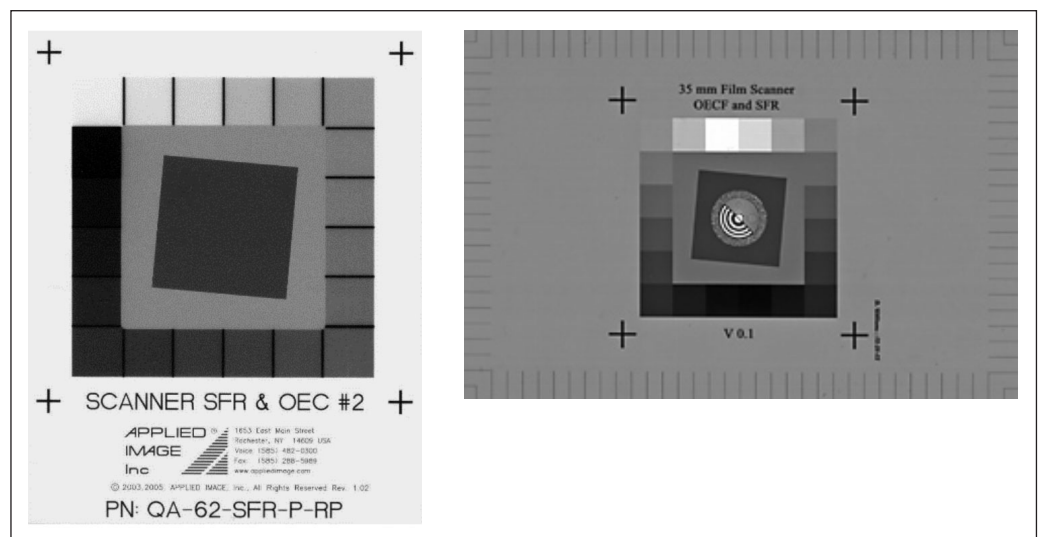
The header of the digital image must state the actual image resolution. This can be obtained from the slanted-edge target, using appropriate software, or by subsequent measurement using a scanned ruler. The header also includes the name of the Contracting Authority and the brand and type of the hardware with which the digital images were produced.

SFR/detail reproduction

The SFR efficiency must be at least 90% at every resolution. The SFR on the Nyquist frequency should not exceed 0.35. The SFR on the $\frac{1}{4}$ sampling should be no less than 0.30. The difference between the horizontal and vertical SFR must never exceed 0.15.

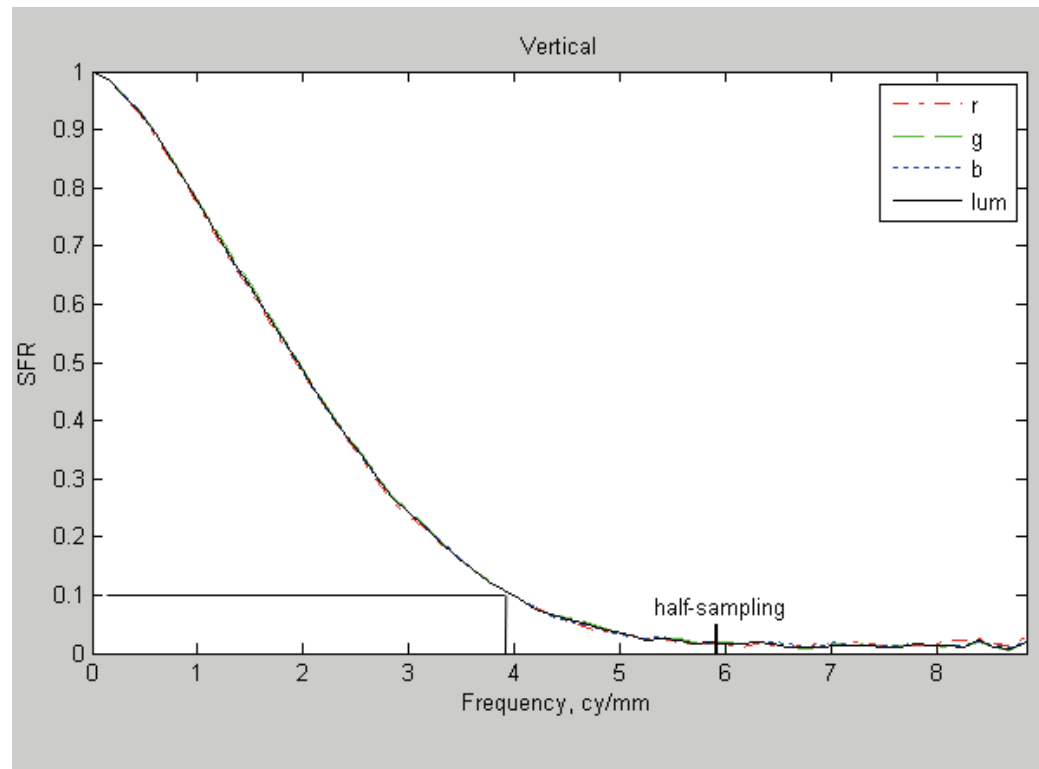
The number of line pairs per millimetre (lp/mm) is determined at the SFR 0.1 point by measuring the SFR based upon a slanted-edge target.

Figure 1
Examples of slanted-edge targets and transparencies (right) and prints (left).



In accordance with the protocol described in ISO 16072-2[®], the measurement is performed using – for example – ImCheck[®] software, which calculates the SFR for three RGB channels and luminance in both horizontal and vertical directions.

Figure 2
Cropped image output of the vertical SFR analysis



There are a number of important points in the above graph.

- The half-sampling point (Nyquist frequency) gives the maximum achievable lp/mm with the relevant resolution (here 5.9 lp/mm with a resolution of 300 ppi).
- The SFR 0.1 point (R10), or the Rayleigh criterion, is the point at which differences can still just be perceived. In the above example, this point is at 3.9 lp/mm. That is an efficiency of 66%.
- At the quarter-sampling point (the half Nyquist frequency, here approximately 3 lp/mm), the SFR must be no less than 0.30.
- Aliasing area: these are all frequencies higher than the Nyquist frequency. The SFR here must not exceed 0.35.
- Horizontal and vertical SFR curves: the mutual differences between horizontal and vertical must not exceed 0.15 for any frequency.

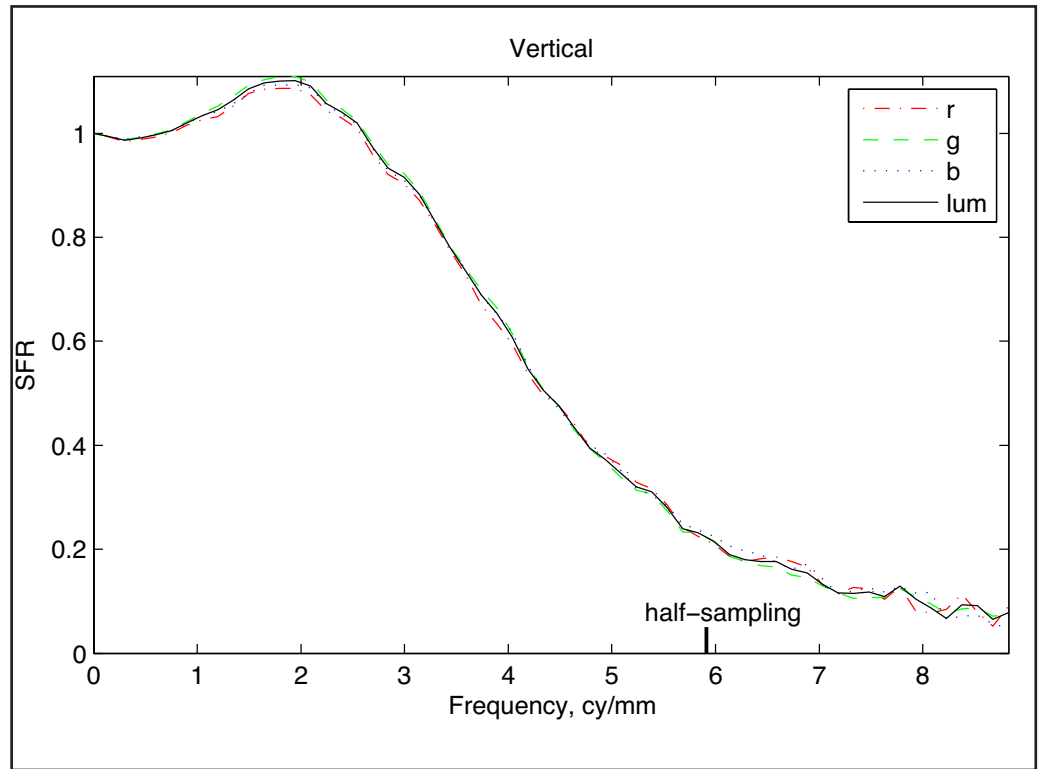
The efficiency is the percentage of the achieved lp/mm at the SFR 0.1 point, in relation to the Nyquist frequency. If the efficiency is low, eg. 50%, then there is great loss of detail. If digitisation is performed at 600 ppi and the efficiency is 50% both horizontally and vertically, then the number of line pairs per millimetre is $0.5 \times 11.8 = 5.9$. This is equal to an image digitised at 300 ppi with an efficiency of 100%. However, the 600 ppi image file is four times as large. A 300 ppi image which is resampled to 600 ppi using software contains approximately the same detail as a 600 ppi scan with an efficiency of 50%. It is necessary to achieve an efficiency of at least 90%.

Sharpening

Sharpening of production masters is not allowed. Given that internal sharpening mechanisms cannot be switched off in some digital cameras, in such instances a small margin of sharpening is permitted; this is limited to 1.1 and can be read from the SFR curve generated by the ImCheck software for the three colour channels (RGB) and the luminance.

This is visible as the 'hump' in the curve in the following example. The digital image is sharpened in the vertical direction to an SFR value of approximately 1.1. For red (r), green (g), blue (b) and luminance (lum), the value is approximately 1.1.

Figure 3
An SFR graphic.



Colour misregistration

Colour misregistration arises when the RGB channels do not run entirely synchronously. There is then a coloured 'edge' visible around contrast-rich sections.

Colour misregistration can be determined by means of the slanted-edge target and is measured using, for example, the ImCheck software. The colour misregistration is determined per colour channel in both horizontal and vertical directions.

A maximum deviation of ± 0.35 in both the horizontal and the vertical direction is permitted.

Figure 4
An example of high colour misregistration.



Digital imaging artefacts

Digital imaging artefacts are a set of deviations which share the characteristic that they must be identified visually. The following artefacts are not permitted.

- Horizontal and vertical stripes.
- Pixellation distortions.
- Halation disturbances.
- Blocking and other deformation defects such as wave motions (moiré) and curving.
- Reflections.

The above list is not exhaustive.

File format

The file format in which digitisation must be carried out is TIFF version 6.0 uncompressed.

The TIFF file must meet the TIFF 6.0 specifications.

(see <http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf>). The file format for the derivatives is JPEG lossy compression, baseline 1:10.

File names for digital images

Retaining the link between the digital image and its original is crucially important. That link, and also those with the associated metadata or signifiers, are guaranteed by including primary information such as the inventory number and/or photograph number in the file name. This also allows the opportunity to add metadata on-screen, based upon the characteristics of the digital images.

Each digital image must have a unique file name. The Contracting Authority determines the naming format to be used for each (sub)project.

An example of a file name:

NL-HaNA_2.24.03_34.tif

This states:

Contracting Authority_collection_photograph number.extension

Order of digital images from the source material

The order of the digital images must comply with the requirements set by the Contracting Authority, which indicates how they should be sequenced.

Frequency of test scans

Test scans are carried out at the start of every production day, after the digitising equipment has been switched off and whenever its hardware or software settings have been changed.

Please refer to the relevant chapters for information on the test targets.

Inspection of test scans

It is recommended that measurements be checked immediately after producing the test scans, so that any deviations in the hardware or software can be detected and remedied at an early stage. The measurement results from the test scans must be submitted together with the progress reports, and possibly also with the Final Report. The parties are expected to reach agreements on the form in which these results are submitted to the Contracting Authority. This may differ per test scan. See also 'Inspection by the Contractor'.

Order of test scans

The test scans must be ordered carefully, so as to enable inspection of production quality. The target files must be saved in a separate directory. It is important that there is an unambiguous relationship between the digital images and their associated Test Scans. The relationship between the test scans and the associated digital images could potentially be determined by a concordance. This must be negotiated with the Contracting Authority and put down in writing.

File names of test scans

The Contracting Authority determines how the test scans are named. The elements to be incorporated in the file names are: the hardware used or the name of the workstation; the resolution; the type of target; and metadata for the source material to be digitised.

The Contracting Authority determines the file naming format to be used for each project.

An example of a file name:

Scanner 2_2.24.03_0600_0002_colour.tif

This states:

Workstation_collection_resolution_second test cycle for the resolution concerned_target type.extension

2.5 Logistics

Glass plate negatives

Because of the fragile nature of the material, transportation of glass plate negatives must be kept to a minimum. Consequently, their digitisation takes place at the Contracting Authority.

Air quality and hygiene

The relative humidity in the environment where the source materials are located during shipment, storage and processing must be no greater than 65% and no less than 30%. The source material must not be exposed to direct or indirect sunlight. The temperature to which source material is exposed must not normally exceed 30° Celsius. During digitisation, however, the temperature may occasionally reach 40° C. And during shipment the temperature may reach 35° C for limited periods.

Objects must not be stored against an external wall, due to condensation risk, or in the vicinity of radiators or other heat sources. Air quality variations must be limited. Risks such as flooding, fire and burglary must be minimised as much as possible.

Biological threats such as vermin, insects and mould must be prevented as much as possible through best-practice hygiene.

Internal transport

The Contractor guarantees maximum effort to ensure the security of the source material during shipment, processing and at all other times.

After digitisation, the source material is returned to the Contracting Authority in appropriate packaging.

Shipment

The Contracting Authority ensures that the photographic material is packed in archive or comparable boxes. The Contractor is responsible for shipping the source material, and also making it ready for shipment. The following precautions must be taken in this regard.

- Climatic conditions as per requirements.
- Shock and impact-resistant packaging during shipment.
- Shipment in universal, convenient and identical crates, cases or boxes.
- Protection against weather (rain, wind and sun), including during loading and unloading

All costs associated with transportation of the source material are payable by the Contractor.

These include:

- costs of transportation;
- costs of packaging;

- insurance;
- valid licences (eg. transportation of dangerous goods), if applicable;
- customs procedures, if applicable;
- import and export duties, if applicable;
- excise duties, if applicable.

The Contractor must collect the source material from the partner organisations in Amsterdam and/or The Hague, and return it after processing, as per the specifications contained in the Descriptive Document.

The Contracting Authority advises on the packaging to be used in order to maintain the quality of the transported material.

Delivery of digital files and source material

The Contractor and the Contracting Authority make agreements concerning the supply of digital files, including any part deliveries. The Contractor ensures temporary back-up of the digital files until one month following approval of the full or part delivery by the Contracting Authority. The Contracting Authority carries out an inspection within two months following delivery.

The digital files must be readable as delivered on the computer hardware used by the Contracting Authority: Windows PC FAT 32 or NTFS with a master boot record (MBR). The digital files must be supplied on external hard disks with a USB 2.0 connection; the Contracting Authority provides hard disks for this purpose. Any problems regarding the compatibility of plugs and voltages must be resolved by the Contractor. The Contracting Authority and the Contractor may decide, after mutual consultation, on a different method of delivering the files – for instance, by FTP or storage on demand.

A folder containing the number of the collection and the box or inventory number is created for each box or inventory number in which the associated files are to be stored. See also 'Order of digital images' and 'Order of test scans'.

The source material is returned to the Contracting Authority after the digital files have been approved.

Property rights

The Contracting Authority at all times retains ownership of intellectual and physical property rights of the source material, and also acquires the full property rights in the digital images produced. The copyright to an image, and in the digital images created from it, is retained without prejudice by the relevant copyright holder.

The Contractor is not permitted to use digital images, their derivatives or the photographic source material in any way. The Contractor destroys the digital images, and also any derivatives, one month after they have been approved by the Contracting Authority.

Whenever the Contracting Authority requests that files be destroyed, the Contractor is required to overwrite them; that is, it must apply a software procedure that replaces the digital images and their derivatives with meaningless data. The Contractor agrees only to use overwriting software that (1) is approved by the Contracting Authority and (2) is compatible with the specific hardware intended for overwriting.

Transfer Document

Responsibility for the photographic material rests with the Contractor throughout shipment, temporary storage and digitisation. Prior to their transfer, the Contracting Authority expects the Contractor to sign a Transfer Document confirming that the source materials have been delivered in good order and in the agreed quantities (number of boxes, or possibly number of individual items). Upon return of the source materials, the Contracting Authority checks the number received and their packaging. A confirmation of receipt is then signed if the consignment has been received in good order. In the event that quantities are incorrect or damage is found, compensation may be demanded up to a maximum of € 10 per object.

Progress reports on digitisation and project consultations

The Contractor reports on its progress on a monthly basis. This report clarifies the current state of affairs, the progress made so far and any particular details. Any significant deviations from the scheduled workflow must be explained.

The method by which the measurement results for the test scans are made available is determined in consultation with the Contracting Authority.

Final Report on digitisation

At the end of the digitisation project, the Contractor submits a Final Report to the Contracting Authority in digital form. This includes the following content and technical information.

Content

- The digitised collection.
(The Contracting Authority determines the details to be included here).
- File names from to
- *(Several series may be possible).*
- Name of the digitising company.
- Year of digitisation.
- Number of digital images.
- Number of source objects.
- Name of the Contracting Authority.

Technical

- Resolution per project section.
- Date of technical inspection (month and year).
- Any outstanding measurement results from the test scans.
- The digitising equipment used (cameras, digital camera backs, etc.)
- The colour temperature of the illumination used, in degrees Kelvin.
- The colour rendition index (CRI) of the illumination used.

The report is submitted in a format agreed with the Contracting Authority.

2.6 Testing

In order to check its ability to fulfil the contract properly, a prospective Contractor is required to complete a test following provisional acceptance of its tender. The procedure for this is as follows.

After provisional award has been made but before the Framework Contract is signed, the successful Tenderer (prospective Contractor) must demonstrate that it is able to carry out digitisation in accordance with the contract. The Tenderer has a total of two months in which to do this. The Contracting Authority makes original photographic material available for this purpose. This two-month period begins as soon as the Tenderer has received the test targets and software from the Contracting Authority.

Before digitisation can begin, the Tenderer must align and calibrate the necessary equipment. The Contracting Authority submits test targets for this purpose, as well as the software needed in order to conduct measurements on them.

Once the illumination uniformity and OECF have been established, the Contracting Authority assists with further preparations for digitisation. At the same time, the Contracting Authority may give brief instructions regarding the test scans, their measurement and the interpretation of the data. Representatives from the Contracting Authority will be available at the site where the Tenderer intends to digitise the source materials for a maximum of five consecutive working days. However, this attendance should not be required whilst the equipment is being aligned and calibrated.

Once alignment and calibration are complete, the test scans are made and they and their measurement results are delivered to the Contracting Authority. It is based upon these images that the Contracting Authority determines whether the preparations for digitisation have been completed successfully and the measurement results comply with the requirements contained in the Descriptive Document. If the test scans are rejected, the Tenderer is given up to three further opportunities to correct the problems, providing it does so within the period available for the test phase.

Following these preparations, the Tenderer digitises sample photographic material in accordance with the requirements contained in the Descriptive Document. That sample consists of no more than 25 items, which are supplied by the Contracting Authority.

The resulting digital images and their derivatives are delivered to the Contracting Authority along with the test scans and their measurement results. The results are assessed using the procedure described in the Descriptive Document. If this production sample is rejected, the Tenderer is given up to two further opportunities to correct the problems, providing it does so within the period available for the test phase.

The Contractor ensures that the original photographic material and – depending upon the award – any test targets are returned to the Contracting Authority in good order. This constitutes a part of the test.

3 Photographic prints, various sizes, black and white, and colour

3.1 Results

The Contractor produces digital images of photographic material based upon the requirements contained in the Descriptive Document. These images are the production masters (TIFF revision 6.0 quality) and undergo limited processing; specifically, they are cropped.

The basic standard is that, roughly speaking, it should be possible to produce a print of the digital image in approximately A4 format, with a resolution of 300 dots per inch (dpi). Given that the source material varies in format, images with different resolutions are actually produced.

A derivative (JPEG baseline compression 1:10) is made of each production master, and both masters and derivatives are supplied to the Contracting Authority.

Making good test scans, giving correct file names and proper organisation of the digital images are all part of the test exercise.

The Contractor ensures temporary back-up of the digital files until one month following approval of delivered production masters and derivatives by the Contracting Authority. The Contractor must collect the source material from the Contracting Authority and deliver it after processing in accordance with specifications contained in the Descriptive Document. The partner organisations advise on the packaging to be used in order to safeguard material during transportation.

3.2 Specifications for the digitisation of photographic prints

Software

It is strongly advised that the most recent version of any software be used when assessing and, if need be, post-processing images. The Contracting Authority uses the following colour settings in Adobe Photoshop for assessments. (See figure 5 on the next page).

The Contracting Authority uses the following hardware and applications for quality control.

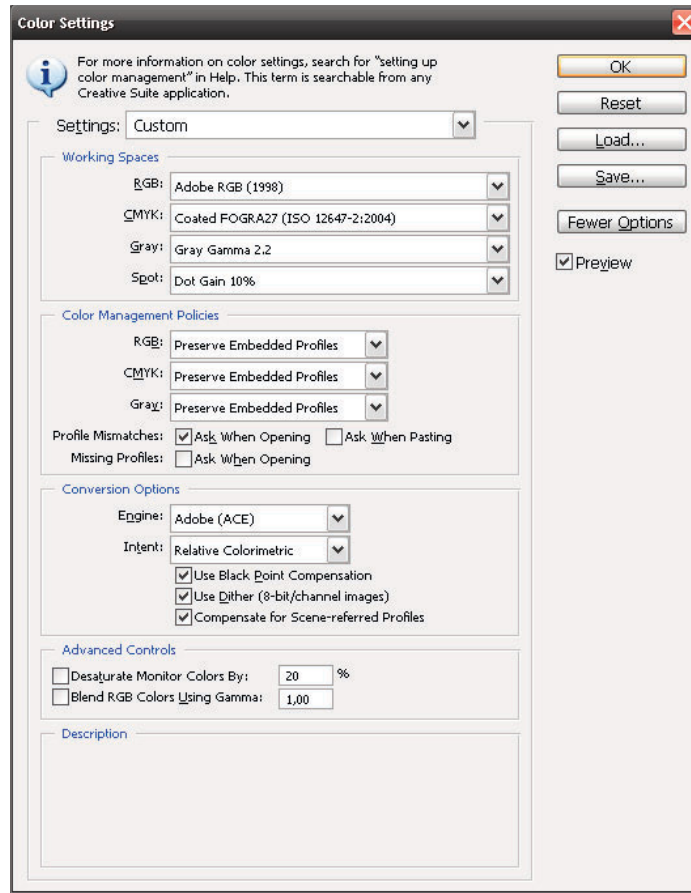
- Monitor: EIZO CG221.
- Eye One spectrophotometer for calibration of the monitor.
- EIZO ColorNavigator for calibration of the monitor.
- Adobe Photoshop CS4 Extended to measure pixel values, pixel value distribution, standard deviation, angle and distance.
- ImCheck (*Copyright: Peter D. Burns*) to check detail reproduction (SFR), efficiency, noise and colour misregistration. This software is provided by the Contracting Authority.
- IE Analyzer 3.10 Colour Module to check colour reproduction. This software is provided by the Contracting Authority.

Software and test targets made available by the Contracting Authority

The following software and test targets are made available to the Contractor to check digital images.

- QA-2M test target for geometric distortion
- QA-62 print slanted-edge target (SFRM-OECF).
- GretagMacbeth ColorChecker SG, a colour chart with 140 patches.
- Kodak Q13 Gray Scale, a greyscale with 20 patches.
- IE Analyzer 3.10 Colour Module, software for ΔE measurement.
- ImCheck software for measurements against SFRM-OECF target.

Figure 5
Screenshot from
Adobe Photoshop CS4.



Resolution of print source material

Resolution depends upon the format of the source material. In principle, material of 180 x 240 mm or larger is digitised at 300 ppi. For smaller material, digitisation is performed such that the digital image is at a minimum of 180 mm x 240 mm x 300 ppi. The maximum resolution for print material is 600 ppi, and for transparent material 2400 ppi. Print source material smaller than 13 x 18 cm is digitised at a resolution of 600 ppi. Possible exceptions to the above rule are photograph albums, album pages and photographs affixed to cardboard. These appear only occasionally. In order to retain their context, the Contracting Authority may decide to digitise these items in their entirety. And it may be decided to digitise them at 450 ppi because the many small photographs on these sheets would be digitised at a relatively lower resolution. The Contracting Authority indicates which items are to be digitised at 450 ppi on a per-project or per-section basis. If the distance to the Source Material is fixed (for instance with flatbed scanners) the principle must be that the Resolution is not interpolated. This will often be the optical Resolution divided by a positive whole number. The manufacturer will be able to give a definitive answer to this. If the specifications of the scanner require such action, deviation from this may be possible in consultation with the Contracting Authority.

Table 1 shows the resolution for different formats in which items must be digitised. If possible, the Contracting Authority supplies the source material sorted according to the required resolution. The Contractor can then work as much as possible with the same hardware and software settings.

Table 1
Resolutions for photo-
graphic print material.

From	Up to and including	ppi *)	Pixels/mm	lp/mm	Efficiency
1.8 x 2.4 cm	≤ 13 x 18 cm		600	23.6	11.8 90%
13 x 18 cm	≤ 18 x 24 cm	450	17.7	8.85	90%
18 x 24 cm	30 x 42 cm	300	11.8	5.9	90%
Album pages etc.	Approx. 22 x 34 cm	450	17.7	8.85	90%

*) Only non-interpolated resolutions may be used. If the hardware makes this necessary, the next higher non-interpolated resolution should be used. For example 480 ppi instead of 450 ppi.

Geometric distortion

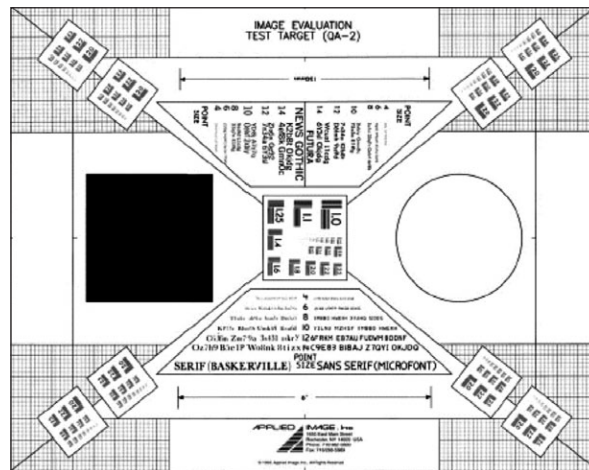
Geometric deformation or distortion occurs in different ways.

- Cushion-shaped distortion: the sides of a square or rectangle are somewhat concave.
- Barrel-shaped distortion: the sides of a square or rectangle are somewhat convex.
- Skew: caused by the recording surface not being parallel to the original.

A maximum deviation of 1% is permitted.

For print photographic material, a geometry test target is used for subsequent measurement of the length and height of the digital image – for example, the QA-2M image evaluation test target or a similar chart.

Figure 6
Geometry test target
for photographic prints.



Tonal rendition (OECF)

The tonal rendition of a digital image is one of the most important technical quality criteria. It is therefore the first parameter to be evaluated in assessing quality. In principle, gamma should be 2.2 across the entire range.

The assessment is based upon comparison between the values of the pixels on a greyscale in a test scan with the calculated pixel values of the original physical greyscale. The Kodak Q13 or Q14 Gray Scale, or a comparable scale, is used for the inspection. These have gradations of 0.1D, starting at D = 0.05 and finishing at D = 1.95. All twenty steps are important. The calculated values are listed below with their permitted tolerances.

For rapid evaluation of the quality of the tonal rendition, begin by assessing four patches. If these patches are positively rated, the next 16 can be assessed. The margins are identical for all patches, namely plus or minus 1/12 stop (D = ± 0.025) minus 3 pixel values for the lowest value. The difference between the pixel values of patch A and patch 1 in the image is of essential importance. This difference is indicated as the highlight gamma.

An explanation and the calculation of the highlight gamma are given below. Also stated are the pixel values in the image within which each of the gradations of the greyscale must fall.

Patch A must retain its minimal cover in the digitised image. The margin of illumination in making the image is also very slight, because the photographic print density of patch A is so small, namely 0.05. The acceptable illumination margin is 1/6 stop and 3 pixel values in total. That means 1/12 stop underexposure minus 3 pixel values and 1/12 stop overexposure. This represents 0.086 and 0.025 in terms of photographic print density.

The pixel value can be calculated using the reflection value. This value depends upon the colour profile you are working in, and upon the bit depth and gamma setting of the monitor. In principle, the colour profile to be used is Adobe RGB 1998, the monitor gamma setting 2.2 and the bit depth 8. After conversion, a density of 0.025 results in a pixel value of 248. And density 0.086 results in a pixel value of 233. The pixel value of patch A on the greyscale in the image must lie

between 248 and 233 (see table below). Naturally, a total margin of $1/6$ f-stop applies to the pixel value of patch 1 and all other patches. The pixel value of patch 1 must be between 224 and 209. The *real* and *theoretical* pixel values (without exposure margin) of patches A and 1 respectively are 242 and 218.

Table 2
Conversion of the greyscale densities to pixel values with the associated tolerances (monitor gamma = 2.2).

Kodak Gray scale	Density	Reflection value	Theoretical pixel value	Maximum permitted pixel value (+ $1/12$ stop)	Minimum permitted pixel value (- $1/12$ stop)	Minimum permitted pixel value - 3 pixel values
A (0)	0.05	0.891	242	248	236	233
1	0.15	0.708	218	224	212	209
2	0.25	0.562	196	201	191	188
3	0.35	0.447	177	181	172	169
4	0.45	0.355	159	163	155	152
5	0.55	0.282	143	147	140	137
6	0.65	0.224	129	133	126	123
M (7)	0.75	0.178	116	119	113	110
8	0.85	0.141	105	108	102	99
9	0.95	0.112	94	97	92	89
10	1.05	0.089	85	87	83	80
11	1.15	0.071	77	79	75	72
12	1.25	0.056	69	71	67	64
13	1.35	0.045	62	64	60	57
14	1.45	0.035	56	57	54	51
15	1.55	0.028	50	52	49	46
B (16)	1.65	0.022	45	47	44	41
17	1.75	0.018	41	42	40	37
18	1.85	0.014	37	38	36	33
19	1.95	0.011	33	34	32	29

The highlight gamma is the quotient of the difference in pixel values between patches A and 1 of the *measured* pixel values in the image and of the *real* or *theoretical* pixel values (measured/theoretical). For example, the difference in the measured pixel values of patches A and 1 in the image is $248 - 220 = 28$. The difference in the real or theoretical pixel values between patches A and 1 is $242 - 218 = 24$. The quotient of the difference in pixel values between patches A and 1 is now $28 : 24 = 1.1$. And the highlight gamma is 1.1. The highlight gamma may vary in size to some extent; this depends upon the quality of the imaging equipment being used. The acceptable value of the highlight gamma is between 0.8 and 1.08.

Table 3
Pixel values.

Sequence of stages	Measured or calculated unit	Acceptable values
1	Pixel value, patch A	248 - 233
2	Pixel value, patch 1	224 - 209
3	Highlight gamma	0.8 - 1.08
4	Pixel value, patch 9	97 - 89
5	Pixel value, patch 19	34 - 29

An image of a greyscale is included below for illustrative purposes.

Figure 7
Example of a greyscale.



Measuring pixel values

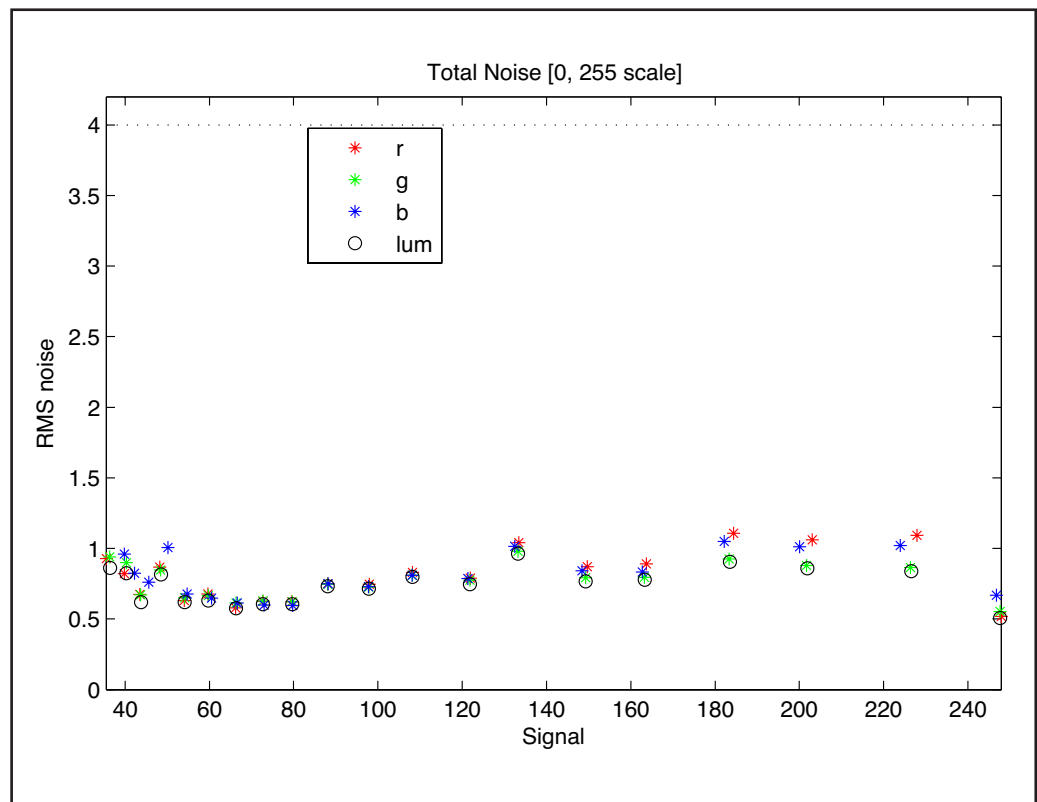
The pixel values are measured with a minimum pixel surface setting of 11 x 11 pixels (using the 'eyedropper' tool in Adobe, for instance). The pixel values are displayed in the information screen. The same colour channel must be used to measure the pixel values and to calculate the highlight gamma in a colour file; it is best to use the channel with the highest pixel values in patch A. In any case the tolerances in pixel values, and therefore also their maximum values, apply to all three colour channels.

Noise

As far as possible, scans need to be noise-free. The maximum noise value is 4. Noise can be described as undesirable light fluctuations in an image that do not form part of the source material. In this respect, the noise may be of a more random or fixed kind. Image noise reduction and noise cleaning processing are not permitted.

Noise can be measured using the greyscale and the slanted-edge software. This calculates the standard deviation (deviation from the average value) in the three RGB channels for each patch in the greyscale. The curve shown below is the output in the slanted-edge software. The standard deviation values are displayed on the Y axis and the reflection values of the greyscale on the X axis.

Figure 8
Noise curve from slanted-edge software.



Because damage and dirt on the target are measured as a deviation, it is absolutely necessary to work with an undamaged, uncontaminated and dust-free greyscale. If working with a glass plate, this must be clean and scratch-free.

The maximum permitted amount of noise is a standard deviation of 4. This figure is based upon the visibility of noise in the image. The acceptable amount of noise in an image is related to the visual experience; it must not (or only barely) be visible, even in darker areas.

Signal-to-noise ratio (SNR)

The SNR gives an insight into the relationship between pixel values ('signal') and the noise value. It can be calculated by dividing the pixel value of a random patch on the greyscale by the corresponding noise value or standard deviation. The standard deviation can be read from the histogram. If, for example, the pixel value of patch 19 is 33 and the noise value is 3, then the SNR $33:3 = 11$. This means that $1/11$ (or 9%) of patch 19 consists of noise. So the higher the SNR, the better the ratio between noise and signal.

The SNR must not be less than 6 for any pixel value of a random patch on the greyscale. If $1/6$ or more of an image is noise, then that amount is so great that it detracts from the visual experience. The SNR and the associated input density give the dynamic range of the scanning or camera system.

The above method is that currently used for print material. Should a better one be developed in the future, the Contracting Authority will adopt that instead.

Illumination uniformity

In order to guarantee even and uniform illumination, a piece of white cardboard must be included as an image filler. This should have an input density between 0.05 and 0.15. A Kodak or comparable greyscale must also be included in the centre base of the image. In order to assess the uniform illumination (with image processing software such as Photoshop), the pixel value must be measured at no fewer than five points using the eyedropper tool, with a minimum surface setting of 11 x 11 pixels. The measuring points are in the centre and at the four corners. If there is any doubt about the quality of the illumination uniformity, more points must be measured.

The difference between pixel values across the image surface must not be greater than approximately 8 per colour channel. This corresponds to a difference in input density of $1/10$ f-stop. The maximum pixel value must not exceed 250.

It is possible that the optical whiteners in the cardboard will result in an incorrect or somewhat deviating ratio of pixel values between the three colour channels. This method is therefore not suitable for assessing colour cast. It is also possible that the optical whiteners will result in an incorrect or somewhat deviating conversion of reflection values into pixel values. It is therefore not advisable to compare reflection and pixel values one to one by the use of white card or paper with optical whiteners, or to perform a one-to-one pixel value comparison of such cardboard or paper with the pixel values of test targets like the Kodak Q13 and the GretagMacbeth ColorChecker SG.

White cardboard or paper will, however, provide only a general impression as to whether the illumination uniformity and colour cast are correct or incorrect. The rule on 8 pixel values must therefore be applied with some discretion.

Colour cast

Just as with illumination uniformity, the potential colour cast needs to be measured and assessed in the centre and at the corners of the total image plane. The maximum permitted colour cast is + 3 and - 3 pixel values difference between the three colour channels per grey patch.

Colour accuracy

In order to guarantee colour accuracy, images are to be taken of a standardised colour chart with 140 patches – for example, the GretagMacbeth ColorChecker SG or similar. Using software, the colours obtained are then compared with their reference values. The Contracting Authority uses the package IE Analyzer 3.10 for this purpose.

The comparison is made in colour area LAB and then in ΔE . The specifications against which the colour is assessed are hue (tint), chroma (colour saturation) and luminance (clarity). Criteria have been drawn up for all three. The acceptable value for colour deviations is an average ΔE of less than 6 with a maximum of less than 15.

The Contracting Authority applies the following basis technique: the measurements are taken in IE Analyzer, in accordance with CIE1976; the white point is 'profile'; and the RGB is converted into LAB using Adobe RGB1998.

Mode

For the colour digitisation of black and white photographic prints, use the following mode settings.

- Colour: 24 bits.
- Colour space: ICC profile Adobe RGB 1998.

For monochrome digitisation, use the following settings.

- Greyscale values: 8 bits.
- Colour space: ICC profile greyscale values gamma 2.2.

The Contracting Authority indicates on per-project, per-archive or per-section basis whether black and white photographic prints are to be digitised in colour or using greyscale values.

For the digitisation of colour photographic prints, use the following mode settings.

- Colour: 24 bits.
- Colour space: ICC profile Adobe RGB 1998.

Image structure and sequence of test scans

Exposure 1:

Illumination uniformity

A clean, smooth piece of white cardboard must be included as image filler, with an input density between 0.05 and 0.15. A Kodak or comparable greyscale must also be included, in the centre or at the bottom of the image. The distance between the cardboard and the lens must be the same as between the source material and the lens during production.

In other words, the reduction factor and resolution used for the test targets must be identical to those used for the exposure of actual source material. This applies to all test targets.

The current greyscale has a Dmax of 1.95. As soon as a suitable scale with a higher Dmax (2.15-2.30) becomes available, that must be used.

Exposure 2:

Tonal capture, colour cast and colour accuracy

These items are assessed from a single image. A piece of white cardboard must be included as an image filler, with an input density between 0.05 and 0.15. There must be a colour card at the centre of the image: the GretagMacbeth ColorChecker SG or a comparable chart. And a Kodak or comparable greyscale must also be included, in the centre or at the bottom of the image.

For resolution details, see exposure 1.

Exposure 3:

Sharpness

A black background must be included as an image filler. There are slanted-edge test targets in the centre and at corners of the image. It is important that these be positioned correctly and that they are straight in relation to the image area. A Kodak or comparable greyscale must also be included, in the centre or at the bottom of the image. For resolution details, see exposure 1.

Exposure 4:

Optical distortion and deformation.

A black background must be included as image filler. There is a QA-2M geometry test target in the centre of the image. This is in A3 format, but can also be used for A4 and A5. Research is being done to find a Test Target for small Source Material. Resolution: refer to exposure 1. For resolution details, see exposure 1.

Imaging method

The photographic prints are exposed against a black background, which may have contrasting horizontal and vertical lines as an aid to keep the source material straight.

Digitisation of photo albums, album pages and photographs affixed to cardboard

From time to time, photo albums, album pages and photographs affixed to cardboard need to be digitised. In these cases, depending upon the context it may be necessary to digitise entire pages or cards. A higher resolution may be desirable in such instances.

Figure 9
Example of an album page (top) and of a photograph affixed to cardboard (bottom).



Other deviations

When bound Source Material is digitised, every effort must be made to prevent that letters in the spine fold become illegible or disappear into the shadow. It is essential to consult the Contracting Authority if this proves to be unavoidable.

3.3 Post-processing digital images of photographic prints

Rotation

Digital images may be rotated in multiples of 90° only, using Adobe Photoshop or similar software. No interpolation of pixels is allowed during this rotation.

Alignment

It is not permitted to straighten images digitally. An alignment deviation of 0.5 degrees is permitted.

Cropping

Cropping entails cutting out the relevant part of a digital image and discarding the irrelevant part. This must be done in such a way that the entire original remains visible, with a small border around it.

Table 4
Inspection
by the Contractor

3.4 Inspection by the Contractor

Target used	Recommended software	Measurement	Results	Text reference
				Frequency of test scans (2.4)
				Order of test scans (2.4)
				File names of test scans (2.4)
				Image structure and sequence of test scans (3.2)
Slanted-edge target	ImCheck	SFR efficiency	Efficiency min. 90%	SFR/detail reproduction (2.4)
Slanted-edge target	ImCheck	SFR aliasing	SFR on Nyquist frequency should not exceed 0.35	SFR/detail reproduction (2.4)
Slanted-edge target	ImCheck	SFR at $\frac{1}{4}$ sampling frequency	SFR at $\frac{1}{4}$ sampling frequency should be no less than 0.30	SFR/detail reproduction (2.4)
Slanted-edge target	ImCheck	SFR mutual difference	Mutual difference in SFR between horizontal and vertical should not exceed 0.15. Curves must not display strong troughs or peaks prior to the Nyquist frequency.	SFR/detail reproduction (2.4)
Slanted-edge target	ImCheck	SFR/sharpening	Max. 1.1	Sharpening (2.4)
Slanted-edge target	ImCheck	Colour misregistration	Max. 0.35 pixels	Colour misregistration (2.4)
Geometry test target	Image processing software	Geometric distortion	Max. 1%	Geometric distortion (3.2)
Greyscale	Image processing software	Tonal rendition	See text	Tonal rendition / measuring pixel values (3.2)
Greyscale	ImCheck	Noise	Max. 4	Noise (3.2)
White paper + greyscale	Image processing software	Illumination uniformity	See text	Illumination uniformity (3.2)
Greyscale	Image processing software	Colour cast	Mutual difference max. +/- 3 pixel values	Colour cast (3.2)
Colour chart	IE Analyzer	Colour reproduction	Average $\Delta E < 6$. Max. $\Delta E < 15$	Colour accuracy (3.2)
Greyscale	ImCheck / Image processing software	SNR	Min. 6	Signal-to-noise ratio (3.2)

The Contractor inspects both test scans and the digital images for completeness and quality in accordance with the requirements set. The checks on the test scans are based upon of the production masters.

See table 4 for a summary of the required measurements for the test scans for prints, as contained in the Descriptive Document. This lists the target used, the software recommended for measurement, the results required and a reference to the location of detailed information in the text.

The Contracting Authority provides the following targets and measurement software.

- QA-2M test target for geometric distortion
- QA-62 print slanted-edge target (SFRM-OECF).
- GretagMacbeth ColorChecker SG, a colour chart with 140 patches.
- Kodak Q13 Gray Scale, a greyscale with 20 patches.
- IE Analyzer 3.10 Colour Module, software for ΔE measurement.
- ImCheck software for measurements against SFRM-OECF and greyscale targets.

It is recommended that the technical targets be checked immediately after recording, so that any deviations in the hardware or software can be detected and remedied at an early stage. The measurement results are submitted to the Contracting Authority.

The Contractor also inspects the digital images for quality and completeness. Should any deviations be detected, the Contractor must inspect the images using the production masters. Once the Contractor has approved them for quality and completeness, the images can be submitted to the Contracting Authority.

3.5 Inspection by the Contracting Authority

Digitisation begins with a test phase. The Contracting Authority is entitled to be present on-site at this stage in the process. Based upon the measurements obtained from the test targets and visual assessment of the digital images and source material, a decision can then be made as to whether to proceed with production.

After a full or partial delivery has been made, a production check is performed prior to its formal acceptance by the Contracting Authority.

The Contractor makes the test scans and their measurement results available to the Contracting Authority (see 'Inspection by the Contractor'), which checks them. If they do not meet the requirements set, the entire production batch with which they are associated is rejected.

Table 5
Random sample sizes,
general test level II.

General test level II		Quality level I		
Batch size	Random sample size	Accepted Number of errors	Rejected Number of errors	Letter
281-500	50	≤ 1	≥ 2	H
500-1200	80	≤ 2	≥ 3	J
1201-3200	125	≤ 3	≥ 4	K
3201-10000	200	≤ 5	≥ 6	L
10001-35000	315	≤ 7	≥ 8	M
35001-150000	500	≤ 10	≥ 11	N

Individual images are also inspected, with random samples taken of production masters. The sizes of these samples per batch are derived from ISO 2859-1: 1999, "Sampling procedures for inspection by attributes – part 1: sampling schemes indexed by acceptable quality level (AQL) for lot-by-lot inspection."

The inspection is based upon the following parameters.

- The size of the random sample must comply with general test level II.
- The acceptable quality level (normal test) is 1.0.

For the random sample sizes and tolerance of errors at general test level II, as per ISO 2859-1, see table 5.

If overall production quality proves to be good, it is possible to change to inspection at general test level I. This provides for the following random sample sizes and tolerance of errors, again as per ISO 2859-1.

Table 6
Random sample sizes,
general test level I.

General test level I		Quality level I		
Batch size	Random sample size	Accepted Number of errors	Rejected Number of errors	Letter
281-500	20	≤ 0	≥ 1	F
500-1200	32	≤ 1	≥ 2	G
1201-3200	50	≤ 1	≥ 2	H
3201-10000	80	≤ 2	≥ 3	J
10001-35000	125	≤ 3	≥ 4	K
35001-150000	200	≤ 5	≥ 6	L

If the acceptable number of errors for a particular batch is exceeded, it is rejected in its entirety. If a batch is rejected after inspection at general test level I, subsequent inspections revert to general test level II.

The Contracting Authority retains the right to carry out more inspections than described above.

Errors must be remedied and redigitisation completed within the time limit agreed for the full or part project.

As well as checking production, the Contracting Authority also inspects the source material for completeness and damage. In the event that quantities are incorrect or damage is found, compensation may be demanded up to a maximum of € 10 per object.

The table on the next page lists the aspects subject to inspection by the Contracting Authority, with the acceptable tolerances and the action to be taken if these are exceeded. All errors detected upon inspection must be remedied by the Contractor.

Table 7
Inspection of photographic
printed material by the
Contracting Authority.

Photographic Prints			
Measurements	Software used	Required result	Remedial action by Contractor, if required
Measurements performed on targets			
Illumination uniformity	Photoshop	Max. approx. 8 pixel values difference between RGB colour channels.	Associated scans must be repeated.
OECF	Photoshop	See table tonal rendition table.	Associated scans must be repeated.
Colour cast	Photoshop	Mutual difference between pixel values max. ± 3 .	Associated scans must be repeated.
SFR efficiency	ImCheck	Horizontal and vertical minimum 90%.	Associated scans must be repeated.
SFR at Nyquist frequency	ImCheck	SFR on Nyquist frequency does not exceed 0.35.	Associated scans must be repeated.
SFR at $\frac{1}{4}$ sampling frequency	ImCheck	SFR at $\frac{1}{4}$ sampling frequency is no less than 0.30.	Associated scans must be repeated.
Horizontal and vertical SFR curves	ImCheck	Mutual difference in SFR between horizontal and vertical does not exceed 0.15. Curves display no strong troughs or peaks prior to the Nyquist frequency.	Associated scans must be repeated.
Sharpening	ImCheck	Does not exceed 1.1 in SFR curve.	Associated scans must be repeated.
Colour misregistration	ImCheck	Does not exceed 0.35.	Associated scans must be repeated.
Noise	ImCheck	Maximum 4.	Associated scans must be repeated.
SNR	ImCheck / Photoshop	Minimum 6.	Associated scans must be repeated.
Colour rendition	IE Analyzer (CIE1976)	Max. $\Delta E < 15$. Average $\Delta E < 6$.	Associated scans must be repeated.
Colour space	Photoshop/JHOVE	ICC profile: Adobe RGB (1998).	Associated scans must be repeated.
Geometric distortion	Photoshop	Maximum deviation 1%.	Associated scans must be repeated.
Measurements performed on production image			
Bit depth	Photoshop	In accordance with order: 8 or 24 bits.	If 16 bit instead of 8 bit, convert to 8 bit. If 48 bit instead of 24 bit, convert to 24 bit.
Colour space (colour)	Photoshop / JHOVE	In accordance with ordered ICC profile: Adobe RGB (1998).	All incorrect scans must be repeated.
Colour space (greyscale values)	Photoshop / JHOVE	In accordance with ordered ICC profile: greyscale gamma 2.2.	All incorrect scans must be repeated.
Production masters file format	Photoshop / calculation	TIFF revision 6.0 without compression.	Repair; if lossy format is used, repeat.
File format derivatives	Photoshop / calculation	JPEG baseline compression 1:10.	Repair.
File names	Screen		Repair.
One-to-one relationship between targets and scans	Screen or concordance	Necessary	Repair.
Agreed folder structure	Screen / JHOVE		Repair.
Header ppi information	Photoshop / JHOVE	Is the same as the actual scan resolution, in accordance with order.	Repair if possible; otherwise repeat.
Header Contracting Authority information	Photoshop / JHOVE	Name of the institution or Contracting Authority.	Repair if possible; otherwise repeat.
Header hardware information	Photoshop/JHOVE	Name of hardware used.	Repair if possible; otherwise repeat.
Straightness	Photoshop ruler	Maximum deviation 0.5 degrees.	Repeat all incorrect scans.
Image orientation	Screen	In accordance with appearance.	Repair.
Crop print	Screen	Small border around image, outside picture.	Repeat if the crop is within the image; repair if the crop is too far outside the image.
Digital imaging artefacts	Screen	Not permitted.	All incorrect scans must be repeated.

4 Film-based negatives and glass plate negatives, various sizes, black and white

4.1 Results

The Contractor produces digital images of photographic material based upon the requirements contained in the Descriptive Document. These images are the production masters (TIFF revision 6.0 quality) and will be subjected to limited processing; specifically, they are inverted and cropped, the black point and white point are set correctly and the gamma value and contrast curve are adjusted to provide a good rendition of tone and contrast.

A derivative (JPEG baseline compression 1:10) is made of each production master, and both masters and derivatives are supplied to the Contracting Authority. Making test scans, giving correct file names and proper organisation of the digital images are all part of the tender exercise. The Contractor ensures temporary back-up of the digital files until one month following approval of delivered production masters and derivatives by the Contracting Authority.

The Contractor must collect the source material from the Contracting Authority and deliver it after processing in accordance with specifications contained in the Descriptive Document. The partner organisations advise on the packaging to be used in order to safeguard material during transportation.

Because of the fragile nature of the material, transportation of glass plate negatives must be kept to a minimum. Consequently, their digitisation takes place at the Contracting Authority.

See the relevant sections below for additional information.

4.2 Specifications for the digitisation of transparent objects

Introduction

A number of parameters are quite easily defined in the case of printed material. The maximum reflection (D_{min}) and maximum black (D_{max}) are given. The white of a photograph has a density D_{min} of approximately 0.05 and the black of a high-gloss photograph may have a density D_{max} of approximately 2.1. When digitising printed material, it is possible to adjust the tonal rendition (OECF) in such a way that the various densities are transposed correctly to pixel values. The gamma of the digital file will be more or less equal to that of the original. By this method, a relatively faithful digital copy of the original is created.

This is not the case with negatives. They are an intermediate product intended to be used in the process of printing on paper. In general, they have a gamma lower than 1. However, this value is not fixed and the 'ideal' gamma has become lower and lower over the years. A gamma of 0.70 was considered to be the optimum for a good print off in the 1970s, but 0.55 had become the standard by the 1990s. Analogue photographers had multicontrast printing paper or paper of different grades at their disposal to make good prints from negatives with either a higher or lower gamma.

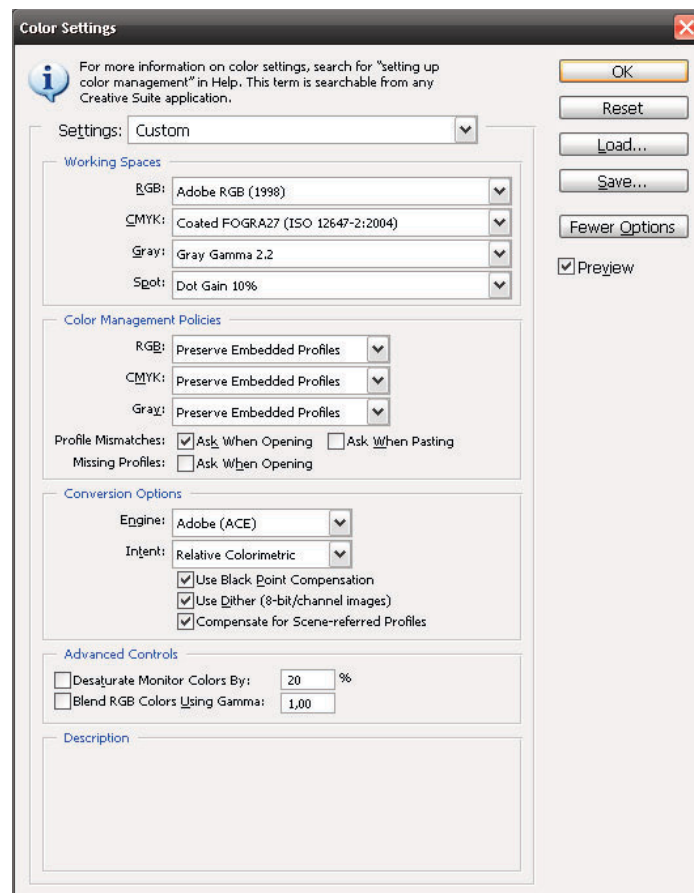
The minimum density of an overexposed or fogged negative, for instance, can be relatively high. The maximum density can also vary enormously, from a D_{max} of 0.5 for an underexposed or underdeveloped negative up to 3.0 for, say, a glass negative or a lantern slide. Negatives must be digitised as if they are positive transparencies, then inverted to obtain a positive image. Because the gamma of a negative is in general lower – much lower, even – than 1,

this produces only a feeble grey positive image. Post-digitisation manipulation of the inverted negative is therefore needed in order to obtain a positive image with good tonal distribution and contrast. See also 'Post-processing'.

Software

It is strongly advised that the most recent version of any software be used when assessing and, if need be, post-processing images. The Contracting Authority uses the following colour settings in Adobe Photoshop for assessments:

Figure 10
Screenshot from
Adobe Photoshop CS4.



The Contracting Authority uses the following hardware and applications for quality control.

- Monitor: EIZO CG221.
- Eye One spectrophotometer for calibration of the monitor.
- EIZO ColorNavigator for calibration of the monitor.
- Adobe Photoshop CS4 Extended to measure pixel values, pixel value distribution, standard deviation, angle and distance.
- ImCheck (*Copyright: Image Science Associates*) to check detail reproduction (SFR), efficiency, noise, DNR, illumination uniformity and colour misregistration. This software is made available by the Contracting Authority.

Software and test targets made available by the Contracting Authority

The following software and test targets are made available to the Contractor to check digital images.

- Applied Image ST-53, a DNR target compliant with ISO 21550 (D = 4.0).
- Nationaal Archief test target for geometric distortion.
- Transparent slanted-edge target (SFRM-OECF).
- Neutral density (ND) filter to determine illumination uniformity.
- ImCheck software to measure SFR, DNR, illumination uniformity and colour misregistration.

Resolution of transparent source material

Resolution depends upon the format of the source material. In principle, material of 180 x 240 mm or larger is digitised at 300 ppi. For smaller material, digitisation is performed such that the digital image is at a minimum of 180 mm x 240 mm x 300 ppi. The maximum resolution for transparent objects is 2400 ppi.

If the distance to the source material is fixed (as with a flatbed scanner, for instance), the principle applied is that the resolution is not interpolated. In other words, it is often the optical resolution divided by a positive whole number; the equipment manufacturer can state whether or not this is the case. If the scanner specifications require such action, deviation may be possible in consultation with the Contracting Authority.

The table below shows the resolution for different formats in which items must be digitised. If possible, the Contracting Authority supplies the source material sorted according to the required resolution. The Contractor can then work as much as possible with the same hardware and software settings.

Table 8
Resolutions for transparent objects.

From	Up to and including	ppi *)	Pixels/mm	lp/mm	Efficiency
1.8 x 2.4 cm	≤ 4 x 4 cm	2400	94.5	47.2	90%
4 x 4 cm	≤ 9 x 12 cm	1200	47.2	23.6	90%
9 x 12 cm	≤ 13 x 18 cm	600	23.6	11.8	90%
13 x 18 cm	≤ 18 x 24 cm	450	17.7	8.9	90%
18 x 24 cm	30 x 42 cm	300	11.8	5.9	90%

*) Only non-interpolated resolutions may be used. If the hardware makes this necessary, the next higher non-interpolated resolution should be used. For example 480 ppi instead of 450 ppi

Geometric distortion

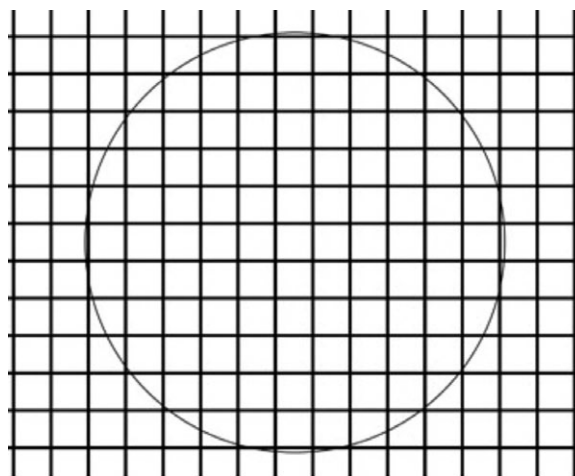
Geometric deformation or distortion occurs in different ways.

- Cushion-shaped distortion: the sides of a square or rectangle are somewhat concave.
- Barrel-shaped distortion: the sides of a square or rectangle are somewhat convex.
- Skew: caused by the recording surface not being parallel to the original.

A maximum deviation of 1% is permitted.

A test target must be used to inspect the degree of geometric distortion. This is provided by the Nationaal Archief.

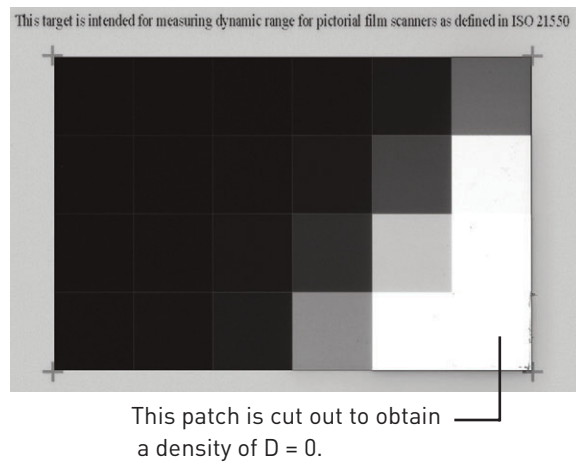
Figure 11
Nationaal Archief transparent test target for geometric distortion



Clipping

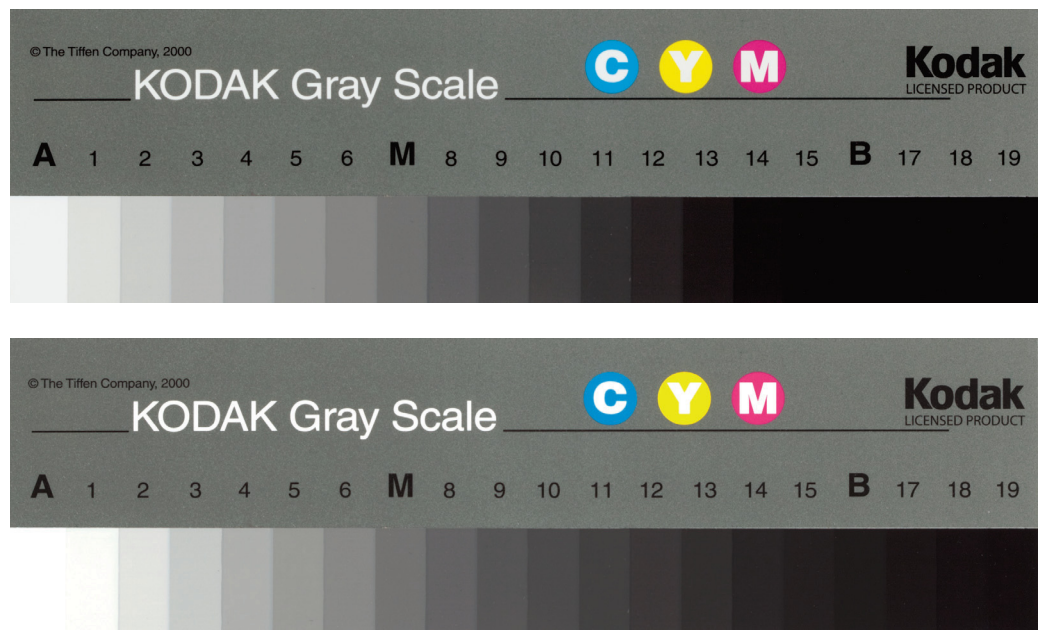
Clipping occurs when the minimum and/or maximum pixel values are achieved prematurely during the digital image processing. This causes loss of information into the shadows and high lights. On the next page is an example of clipping on the ISO 21550 test target. The squares adjacent to the cut-out patch (bottom right) have the same pixel value as that square.

Figure 12
Clipping in the ISO 21550
Test Target



Clipping of relevant image information (so not including hotspots or dust particles) is not permitted. Below are examples of clipped photographic greyscale prints. The pixel value of patch M is the same in both.

Figure 13
Clipping of the dark
sections (top) and the
light sections (below).



A hotspot arises when, for instance, bright sunlight emits into the shot or artificial lighting shines into the camera in an evening photograph. Hotspots and dust particles have a relatively high local density on a source negative. However, hotspots have a very low local density and dust particles a very high local density on source transparencies or lantern slides.

Figure 14
Images with hotspots
(left) and the hotspots
picked out (right).



Illumination uniformity

In order to guarantee even and uniform illumination, a neutral density (ND) filter with a density of $D = 0.15$ must be included to fill the entire format. The exposure must be selected in such a way that the pixel value is between 212 and 235.

The maximum pixel value is 240. To assess uniform illumination, the pixel value must be measured, using ImCheck, at no fewer than five points: in the centre and at the four corners. If there is any doubt about the quality of the illumination uniformity, more points must be measured or the light distribution assessed. The difference between pixel values must not exceed approximately 8 per colour channel.

Transparent film or the ND filter will provide only a general impression as to whether the illumination uniformity is correct or incorrect. The rule on 8 pixel values must therefore be applied with some discretion.

Dynamic range

Dynamic range (DNR) is measured using a modified protocol of ISO 21550, which is incorporated in the ImCheck software provided. Minimum density range should be 3.0 (1000:1), using a signal-to-noise ratio (SNR) criterion of 3.0. The test target used must conform to ISO 21550:2004(E)[®] (see fig. 1 and ISO21550:2004 Photography - Electronic scanners for photographic images - Dynamic Range measurements at www.iso.org) – as do the Applied Image ST-53 and the Esser TE 240 – with a contrast range of 10,000:1 ($D = 4.0$). The resolution is similar to that of the digital images. Image noise reduction and noise cleaning processing are not permitted.

Figure 15
Example of the DNR measurement information presented in ImCheck.

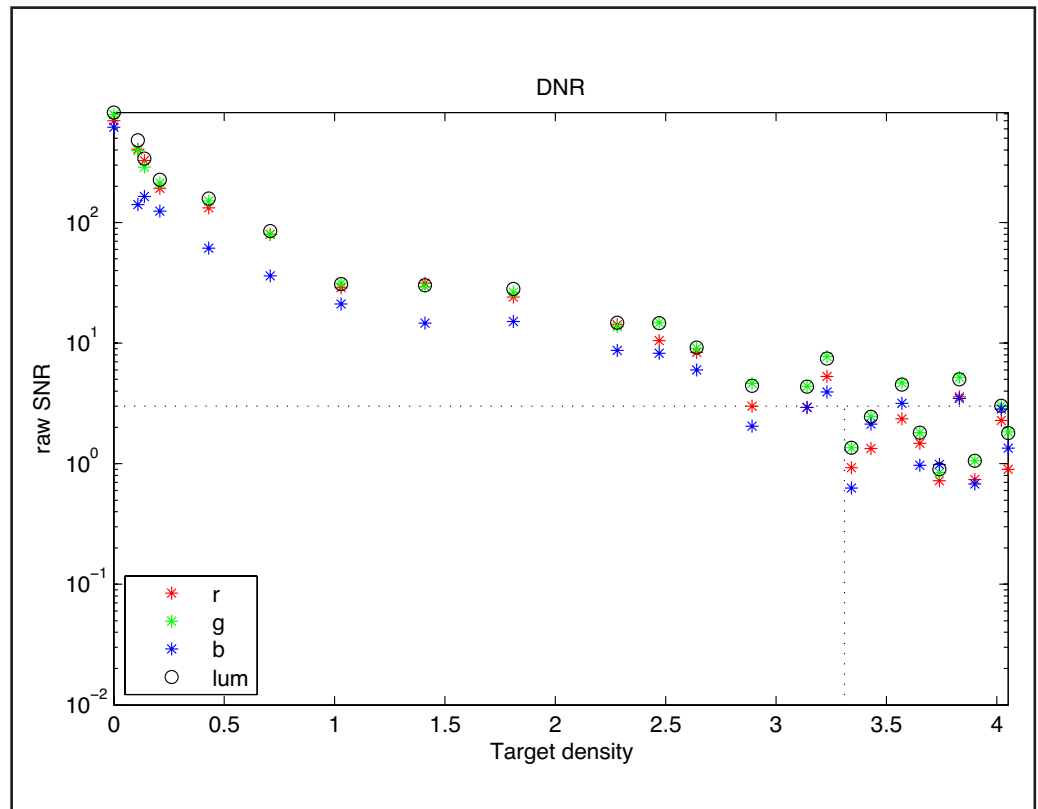
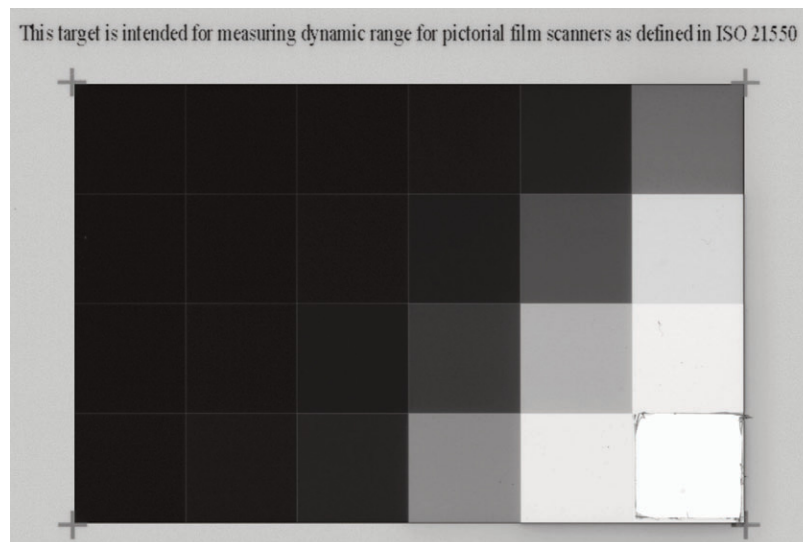


Figure 16
Example of an ISO 21550 DNR target.



Signal-to-noise ratio (SNR)

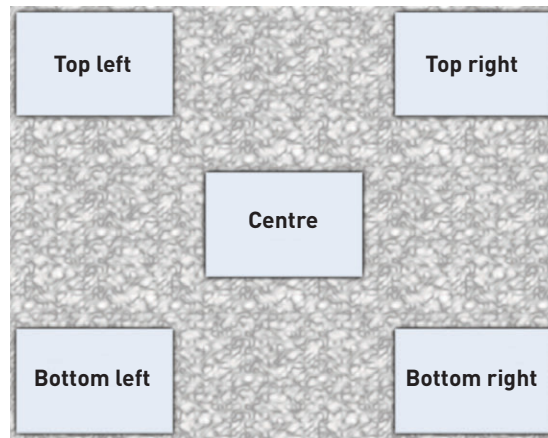
The SNR gives an insight into the relationship between pixel value ('signal') and the noise value, based upon a greyscale. 'Incremental gain' – involving the comparison of two adjacent squares – must be used in the calculation (See ISO 15739, *Electronic still picture imaging – noise measurements*; and ISO 21550, *Photography – electronic scanners for photographic images – dynamic range measurements*). SNR is determined in accordance with ISO 21550. The required minimum SNR for this section of the project is 3.0.

Image structure and sequence of test scans

A number of test targets for transparent objects are available only in miniature format (24 x 36 mm). When larger source material is digitised, five 35mm-format targets must be placed on the scanner as shown below: one at each corner and one in the centre.

Figure 17

Positioning of five small test targets when a 4" x 5" transparent object is to be digitised.



- All transparent test targets must be exposed positively in RGB; they must not be inverted and/or converted to greyscale values.

Exposure 1:

Illumination uniformity

An exposure is made of a filter with a density of 0.15. The pixel values must be between 212 and 235. The maximum permissible difference is approximately 8 pixel values. The distance between the test target and the lens must be the same as between the source material and the lens during production. In other words, the resolution used for the technical targets must be identical to those used for the exposure of actual source material. This applies to all technical targets.

Exposure 2:

Dynamic range and noise

An exposure is made of the centre of the image of an ISO 21550 transmission test target (eg. TE240), with a contrast scope of 10,000:1. The test target must be masked in order to prevent blooming or light overspill. The required dynamic range of 3 must be achieved. For resolution details, see exposure 1.

Exposure 3:

Sharpness, colour misregistration and efficiency.

An exposure is made of the transparent slanted-edge test target. The required sharpness (SFR), colour misregistration, uniformity between horizontal and vertical SFR, SFR on the Nyquist frequency, SFR at the $\frac{1}{4}$ sampling point and efficiency must all be achieved. For resolution details, see exposure 1.

Exposure 4:

Optical distortion and deformation.

An exposure is made of a suitable geometry test target. For resolution details, see exposure 1.

Mode

For the digitisation of transparent material, always use the following mode settings.

- Colour: 48 bits.
- Colour space: ICC profile Adobe RGB 1998.
- Bit depth: 16 bits per colour channel.

The processed digital black and white images are filed in the following modes.

Black and white negatives.

- Greyscale values: 8 bits.
- Colour space: ICC profile greyscale values gamma 2.2.

Black and white negatives, glass plate negatives and lantern slides.

- Greyscale values: 16 bits.
- Colour space: ICC profile greyscale values gamma 2.2.

The Contracting Authority will indicate per project, archive or section whether the digital images are to be supplied in 8-bit or 16-bit mode.

4.3 Post-processing digital images of transparent objects

Producing a positive image from a negative

The digital images are inverted to produce a positive image. The black point and white point must be set properly after cropping, with black no lower than 13 and white no higher than 250. The gamma and contrast value should then be adjusted to produce a good tonal rendition and contrast.

The Contractor must use the verification exposures provided by the Contracting Authorities as a guide in determining the correct rendition of tone and contrast.

Rotation

Digital images may be rotated in multiples of 90° only, using Adobe Photoshop or similar software. No interpolation of pixels is allowed during this rotation.

Alignment

It is not permitted to straighten images digitally. An alignment deviation of 0.5 degrees is permitted.

Cropping

Cropping entails cutting out the relevant part of a digital image and discarding the irrelevant part. In the case of transparent source material, tight cropping occurs within the image and masks may be used during digitisation.

4.4 Inspection by the Contractor

The Contractor inspects the digital images for completeness and quality in accordance with the requirements set. Measurements of the test targets are based upon the TIFFs.

Table 9 summarises those required in the case of transparent objects, as previously outlined.

It states the target used, the software recommended for measurement, the results required and a reference to the location of detailed information in the text.

The Contracting Authority provides the following targets and measuring software.

- Applied Image ST-53, a DNR target compliant with ISO 21550 (D = 4.0).
- Nationaal Archief test target for geometric distortion.
- Transparent slanted-edge target (SFRM-OECF).
- Neutral density (ND) filter D = 0.15 to determine illumination uniformity.
- ImCheck software to measure SFR, efficiency, OECF, DNR, colour misregistration, noise and illumination uniformity.

It is recommended that the technical targets be checked immediately after exposure, so that any deviations in the hardware or software can be detected and remedied at an early stage.

The measurement results are submitted to the Contracting Authority.

The Contractor also inspects the digital images for quality and completeness. Once it has approved them on those counts, they can be submitted to the Contracting Authority.

Table 9
Inspection by
the Contractor.

Target used	Measurement	Results	Text reference
			Frequency of test scans (2.4)
			Order of test scans (2.4)
			File names of test scans (2.4)
			Image structure and sequence of test scans (4.2)
Transparent slanted-edge target (SFRM-OECF)	SFR	Min. 90%.	SFR/detail reproduction (2.4)
Transparent slanted-edge target (SFRM-OECF)	SFR	SFR on Nyquist frequency should not exceed 0.35	SFR/detail reproduction (2.4)
Transparent slanted-edge target (SFRM-OECF)	SFR	SFR at 1/4 sampling frequency should be no less than 0.30.	SFR/detail reproduction (2.4)
Transparent slanted-edge target (SFRM-OECF)	SFR	Mutual difference in SFR between horizontal and vertical should not exceed 0.15. Curves must not display strong troughs or peaks prior to the Nyquist frequency.	SFR/detail reproduction (2.4)
Transparent slanted-edge target (SFRM-OECF)	SFR/sharpening	Max. 1.1	Sharpening (2.4)
Transparent slanted-edge target (SFRM-OECF)	Colour misregistration	Max. 0.35 pixels	Colour misregistration (2.4)
NA geometry test target	Geometric distortion	Max. 1%	Geometric distortion (4.2)
NA test target or filter D = 0.15	Illumination Uniformity	See text	Illumination uniformity (4.2)
DNR target compliant with ISO 21550	DNR	Should be no less than 3.0	Dynamic range (4.2)
DNR target compliant with ISO 21550	Clipping	See text	Clipping (4.2)

4.5 Inspection by the Contracting Authority

Digitisation begins with a test phase. The Contracting Authority is entitled to be present on-site at this stage in the process. Based upon the measurements obtained from the test scans and visual assessment of the digital images and source material, a decision can then be made as to whether to proceed with production.

The Contractor makes the test scans and their measurement results available to the Contracting Authority (see 'Inspection by the Contractor'), which checks them. If they do not meet the requirements set, the entire production batch with which they are associated is rejected.

Individual images are also inspected, with random samples taken of production masters. The sizes of these samples per batch and the assessment criteria used are derived from ISO 2859-1: 1999, "Sampling procedures for inspection by attributes – part 1: sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection."

The inspection is based upon the following parameters.

- The size of the random sample must comply with general test level II.
- The acceptable quality level (normal test) is 1.0.

See the table on the next page for the random sample sizes and tolerance of errors at general test level II, as per ISO 2859-1.

Table 10
Random sample sizes,
general test level II.

General test level II		Quality level I		
Batch size	Random sample size	Accepted Number of errors	Rejected Number of errors	Letter
281-500	50	≤ 1	≥ 2	H
500-1200	80	≤ 2	≥ 3	J
1201-3200	125	≤ 3	≥ 4	K
3201-10000	200	≤ 5	≥ 6	L
10001-35000	315	≤ 7	≥ 8	M
35001-150000	500	≤ 10	≥ 11	N

If overall production quality proves to be good, it is possible to change to inspection at general test level I. This provides for the following random sample sizes and tolerance of errors, again as per ISO 2859-1.

Table 11
Random sample sizes,
general test level I.

General test level I		Quality level I		
Batch size	Random sample size	Accepted Number of errors	Rejected Number of errors	Letter
281-500	20	≤ 0	≥ 1	F
500-1200	32	≤ 1	≥ 2	G
1201-3200	50	≤ 1	≥ 2	H
3201-10000	80	≤ 2	≥ 3	J
10001-35000	125	≤ 3	≥ 4	K
35001-150000	200	≤ 5	≥ 6	L

If the acceptable number of errors for a particular batch is exceeded, it is rejected in its entirety. If a batch is rejected after inspection at general test level I, subsequent inspections revert to general test level II.

The Contracting Authority retains the right to carry out more inspections than described above.

Errors must be remedied and redigitisation completed within the time limit agreed for the full or part project.

As well as checking production, the Contracting Authority also inspects the source material for completeness and damage. In the event that quantities are incorrect or damage is found, compensation may be demanded up to a maximum of € 10 per object.

The table on the next page lists the aspects of transparent material subject to inspection by the Contracting Authority, with the acceptable tolerances and the action to be taken if these are exceeded. All errors detected upon inspection must be remedied by the Contractor.

Table 12
Inspection of transparent material by the Contracting Authority.

The measurements in the upper part of the table below must be performed on images of targets. Those in the lower part of the table will be performed on production images.

Transparent Objects			
Measurements	Software used	Required result	Remedial action by Contractor, if required
Measurements performed on targets			
Illumination uniformity	ImCheck	Max. approx. 8 pixel values difference between RGB colour channels.	Associated scans must be repeated.
SFR	ImCheck	Minimum efficiency is 90%.	Associated scans must be repeated.
SFR	ImCheck	SFR on Nyquist frequency does not exceed 0.35.	Associated scans must be repeated.
SFR	ImCheck	SFR at 1/4 sampling frequency is no less than 0.30.	Associated scans must be repeated.
SFR curves	ImCheck	Mutual difference in SFR between horizontal and vertical does not exceed 0.15. Curves display no strong troughs or peaks prior to the Nyquist frequency.	Associated scans must be repeated.
Sharpening	ImCheck	Does not exceed 1.1 in SFR curve.	Associated scans must be repeated.
Colour misregistrati on	ImCheck	Does not exceed 0.35.	Associated scans must be repeated.
DNR	ImCheck	Is no less than 3.0.	Associated scans must be repeated.
Clipping	Photoshop	See text.	Associated scans must be repeated.
Geometric distortion	Photoshop ruler and screen	Maximum deviation 1%.	Associated scans must be repeated.
Measurements performed on production images			
Bit depth	Photoshop	In accordance with order: 8 or 24 bits.	If 16 bit instead of 8 bit, convert to 8 bit.
Bit depth	Photoshop	In accordance with order: 16 bits per channel.	If 8 bit instead of 16 bit, all incorrect scans must be repeated.
Colour space (colour)	Photoshop / JHOVE	In accordance with ordered ICC profile: Adobe RGB [1998].	All incorrect scans must be repeated.
Colour space (greyscale values)	Photoshop / JHOVE	In accordance with ordered ICC profile: greyscale gamma 2.2.	All incorrect scans must be repeated.
Production masters file format	Photoshop / calculation	TIFF revision 6.0 without compression.	Repair; if lossy format is used, repeat.
File format derivatives	Photoshop / calculation	JPEG baseline compression 1:10.	Repair.
File names	Screen		Repair.
Relationship between targets and scans	Screen or concordance	One to one.	Repair.
Agreed folder structure	Screen / JHOVE		Repair.
Header ppi information	Photoshop / JHOVE	Is the same as the actual scan resolution, in accordance with order.	Repair if possible; otherwise repeat.
Header Contracting Authority information	Photoshop / JHOVE	Name of the institution or Contracting Authority.	Repair if possible; otherwise repeat.
Header hardware information	Photoshop/JHOVE	Name of hardware used.	Repair if possible; otherwise repeat.
Straightness	Photoshop ruler	Maximum deviation 0.5 degrees.	Repeat all incorrect scans.
Image orientation	Screen	In accordance with appearance.	Repair.
Cropping inside	Screen	Tight within the image.	Repeat if picture is overcropped Repair if crop is outside the image.
Clipping	Photoshop levels	No loss of relevant image information.	All incorrect scans must be repeated.
Digital imaging artefacts	Screen	Not permitted.	All incorrect scans must be repeated.
Tonality and contrast of positive image	Photoshop levels and screen	Balanced, retention of detail, good definition	All incorrect scans must be repeated.

5 Current situation and future developments

In November 2009, the consortium partners started with the large scale digitisation of photographs and negatives as part of the Images for the Future program. The guidelines contained in this document have since proven their value, as the digitisation process is progressing smoothly. The digitisation contractors have also become familiar with the procedures and are producing large numbers of images in accordance with our guidelines.

Based on our experience over these recent months, there is only one minor change we would propose to make. When digitising high-gloss photographs, the specified Q13 target is insufficient. Therefore an additional target with a density of $D = 2.1$ has been added to the greyscale in order to enable defining the OECF at high densities.

A number of developments in the field of digital imaging are possibly relevant for guidelines updates. For example, we are currently investigating whether the new Universal Test Target (UTT), together with its accompanying software, can be used in digitising photographs. The UTT combines all the necessary targets in a single package.

The OECF tolerances for photographs are still based upon f-stop settings, in accordance with the lighting system of an analogue camera. However, ΔL -based tolerances reflect more closely the perception by the human eye. Therefore, it would be preferable to use this system for our guidelines.

Another relevant development is the fact that the ECI RGB v2 colour space profile is increasingly becoming the standard. Again, we are investigating whether this can be implemented.

Finally, it must be stressed that the digitisation of cultural heritage requires considerable and specific knowledge on the part of both contractor and principal.

Colophon

Issued by

Nationaal Archief
Prins Willem-Alexanderhof 20
P.O. Box 90520
2509 LM The Hague
The Netherlands
www.archief.nl
<http://www.beeldenvoordetoekomst.nl>

Authors

Joop Korswagen
Liesbeth Keijser

With thanks to

Margot Knijn, Netherlands Institute for Sound and Vision
Emjay Rechsteiner, EYE Film Institute Netherlands
Soeluh van den Berg, EYE Film Institute Netherlands
Hans van Dormolen, Metamorfoze/Koninklijke Bibliotheek
Don Williams, Image Science associates
Peter Burns, Carestream Health, Inc.
Josefien Schuurman, Nationaal Archief
Paul Brood, Nationaal Archief

Translation

UvA Vertalers, Amsterdam
Foekje Boersma, Nationaal Archief

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Design

studio@arnogeels.nl (The Hague)

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IMAGES FOR THE FUTURE