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Information technology — Biometric data interchange formats —

Part 5: Face image data

AMENDMENT 1: Conditions for taking photographs for face image data

Technologies de l'information — Formats d'échange de données biométriques —

Partie 5: Données d'image de la face

AMENDEMENT 1: Conditions de prise de vues pour données d'image de la face

Reference number
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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Amendment 1 to ISO/IEC 19794-5:2005 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 37, *Biometrics*.

Introduction

This part of ISO/IEC 19794 is intended to provide a Face Image Format for face recognition applications requiring the exchange of face image data. Its typical applications include:

a) Human examination of high resolution facial images;

b) Human verification of identity;

c) Computer automated face identification;

d) Computer automated face verification.

To enable applications on a wide variety of devices, including devices that have limited data storage, and to improve face recognition accuracy, ISO/IEC 19794-5 specifies not only a data format, but also scene constraints (lighting, pose, expression, etc.), photographic properties (positioning, camera focus, etc.), and digital image attributes (image resolution, image size, etc.).

This part of ISO/IEC 19794 includes an informative annex, Annex A, entitled “Best practices for Face Images”. Although Annex A provides guidance on topics such as subject pose and expression, image compression ratio, color, geometric distortion, spatial resolution and head size, it does not guide photographers or the designers and operators of photo booths concerning how, for example, they might arrange lighting and reflective surfaces relative to the camera and subject. It also doesn’t provide specific advice on the acceptable amount of variation in illumination across the face, on how to avoid shadows on the face or background, or on a user interface that would ensure proper head positioning.

This Amendment is Annex B to ISO/IEC 19794-5 and is entitled “Conditions for taking photographs for face image data”. It provides expert guidance for the design of photographic studios, photo booths and registration offices and, as such, it supplements the information provided in this Part of ISO/IEC 19794. It also provides guidance on printing quality and on scanning printed face photographs.

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Add the following Annex after Annex A.

Annex B

(informative)

Conditions for taking photographs for face image data

B.1 Scope

The purpose of this annex is to provide expert guidance (i.e., best practices) for the photography of faces, especially when the resulting images are to be used for purposes of identification, either by automated face recognition systems or by human viewers. This guidance is intended for owners and operators of photography studios, photo stores and other organizations producing or requiring either conventional printed photographs or digital images of faces that may be used in applications for passports, visas, or other identification documents and when those images are required to conform to the frontal image types of this part of ISO/IEC 19794. This guidance is also intended for the designers and operators of photo booths, if those booths are required to provide face images conforming to the specifications of this standard. This annex may also be appropriate source material to application developers, application profile standard developers, or others making more general use of this standard.

There are many factors that affect face recognition system performance, including the individual's appearance, such as his or her facial characteristics, hair style, and accessories, and the acquisition conditions, such as the camera's field-of-view, focus, depth-of-field, background, and lighting. The acquisition conditions have, potentially, a greater influence on face recognition accuracy than the individual's appearance and, of course, are controllable by the preparer of the face images.

This annex provides recommendations for acquiring two-dimensional (2D) face images directly with an analogue, digital, or video camera, as well as for image data acquired through traditional photo printing and digital scanning. [The acquisition of three-dimensional (3D) images is out of the scope of this annex.]

This annex may also be appropriate source material for application developers, application profile standard developers, or others making more general use of this standard.

B.2 Photography recommendations

This clause provides recommendations for photographing (acquiring) face images in a portrait studio, photo store, photo booth, registration office, or other facility. Guidance concerning the positioning of the subject and camera is provided, as well as several examples of alternative lighting arrangements. The intent of this guidance is to ensure that the subject's face is properly positioned and uniformly illuminated, thereby producing images that are compliant with this International Standard and are without shadows or hot spots on the face or excessive glare in eyeglasses.

B.2.1 Recommendations for a photo studio or store

A photo studio or a photo store is typically a professionally operated facility, equipped with an analogue or digital camera, multiple adjustable light sources, a suitable background or backdrop cloth, and subject positioning apparatus designed to obtain high quality portraits. This section provides expert guidance for the owners and operators of such facilities when they must produce photographs compliant with the requirements of this standard.

B.2.1.1 Recommended positioning and distance between camera and subject

The following recommendations concern the positioning of the subject and the camera.

— The camera-to-subject distance should be within the range of 1.2 to 2.5 m. Arranging the lighting without creating shadows will likely be difficult if the camera is placed any closer to the subject.

— Proper focus and depth-of-field will be assured by pre-focusing the lens at the distance of the subject's eyes and by selecting an appropriate aperture (F-stop) to ensure a depth-of-field of at least 10 centimetres, or approximately the distance from a subject's nose to ears. The depth-of-field of a lens is dependent upon its focal length, its effective aperture, and the focus distance. Point sources which are closer or farther than the distance at which a lens is well focused will be blurred, with the extent of the blur described by a "circle of confusion." If the maximum diameter of the circle of confusion is limited by, for example, the spacing between adjacent pixels in a CCD image sensor, the front and rear distances from the plane of optimum focus that produce acceptably focused images can be determined. The sum of these front and rear distances is the depth-of-field (D_{DoF}).

$$D_{DoF} = D_{front} + D_{rear}$$

$$D_{front} = \frac{cFs(s-f)}{f^2 + cF(s-f)}$$

$$D_{rear} = \frac{cFs(s-f)}{f^2 - cF(s-f)}$$

where:

D_{front} = the front focal distance, the distance from the plane of focus to the plane closest to the lens that is still in acceptable focus,

D_{rear} = the rear focal distance, the distance from the plane of focus to the plane farthest from the lens that is still in acceptable focus,

c = the diameter of the circle of confusion,

s = the distance from the lens to the object plane (subject's face), and

$F = f/a$ is the F-stop, the lens focal length f divided by the effective lens aperture a

Figure B.1 illustrates these dimensions.

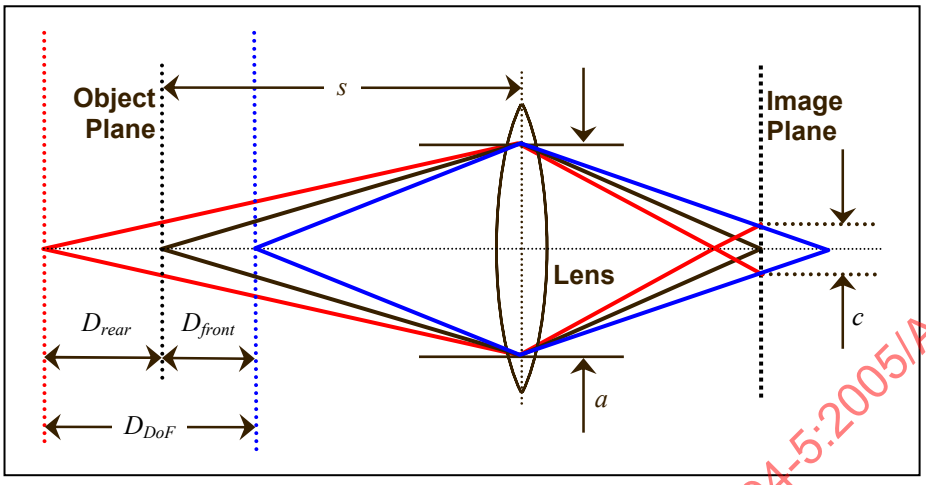


Figure B.1 — Dimensions for depth-of-field calculations

- The optimum height of the camera is at the subject's eye-level. Height adjustment can be done by either using a height-adjustable stool or adjusting the tripod's height.
- The subject should be instructed to look directly at the camera and to keep his or her head erect and shoulders square to the camera. The rotation of the head should conform to the requirements of 7.2.2.

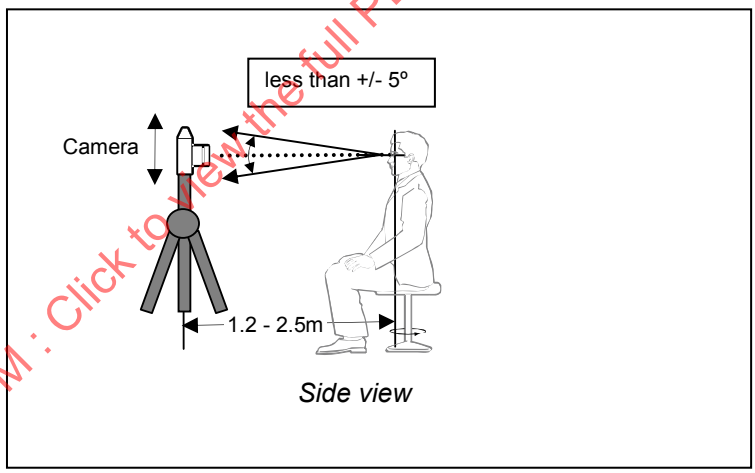


Figure B.2 — Preferred distance and alignment of camera and subject

B.2.1.2 Example of exposure metering at various spots on a subject

The figure below illustrates exposure value (EV) measurement at four spots on a subject's face, namely the left and right cheeks, forehead, and chin. The measurements may be made by placing an incident light meter at the position of a subject's face and pointing the meter towards the camera. The four readings should be within 1 EV of one another. If they are not within 1 EV, the lights should be repositioned more symmetrically about the subject-to-camera line.

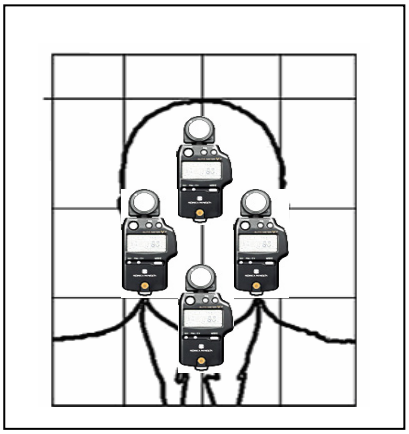


Figure B.3 — Positions of incident light meter for exposure value measurement

EV is the value given to any combination of shutter speed and aperture (F-stop) that results in the same exposure. By definition, an EV value of 0 corresponds to a shutter speed of 1 second and an aperture of F1.0, for a film speed or equivalent image sensor sensitivity of ISO 100. EV is defined by the following equation:

$$\mathrm{EV} = Log_2\left(\frac{\mathrm{F}^2}{\mathrm{T}}\right) = 2Log_2(\mathrm{F}) - Log_2(\mathrm{T}),$$

where F is the F-stop setting and T is the exposure time. A change of 1 EV corresponds to a one F-stop aperture increase or decrease or a halving or doubling of the exposure time.

B.2.1.3 Example configurations for a photo studio or store

Described below are three examples of lighting and subject and camera positioning that are applicable to photographic studio businesses, as well as for some photofinishers that might offer identification photographs, in addition to their main business of material sales and film developing and printing. Example 1 is a single-light arrangement in which the placement of a panel of reflective material is used to provide more balanced lighting. Example 2 is a two-light arrangement with a lower reflective panel providing illumination to the region under a subject's chin. Example 3 is the same as Example 2, but with a third light behind the subject to eliminate shadows on the background material. Several recommendations for camera and subject positioning are also provided below.

B.2.1.3.1 Example 1: Proper lighting arrangement with a single light

In this arrangement, illustrated in Figure B.4, a single light and multiple reflector panels are employed to illuminate the subject's face uniformly. The light, shown with a lamp reflector, should be placed approximately 35 degrees above the line between the camera and the subject and be directed toward the subject's face at a horizontal angle of less than 45 degrees from the line. A reflector panel should be placed on the subject's opposite side to prevent shadows on the face. As an option, an additional reflector may be placed below and in front of the subject's face to illuminate the area around the chin.

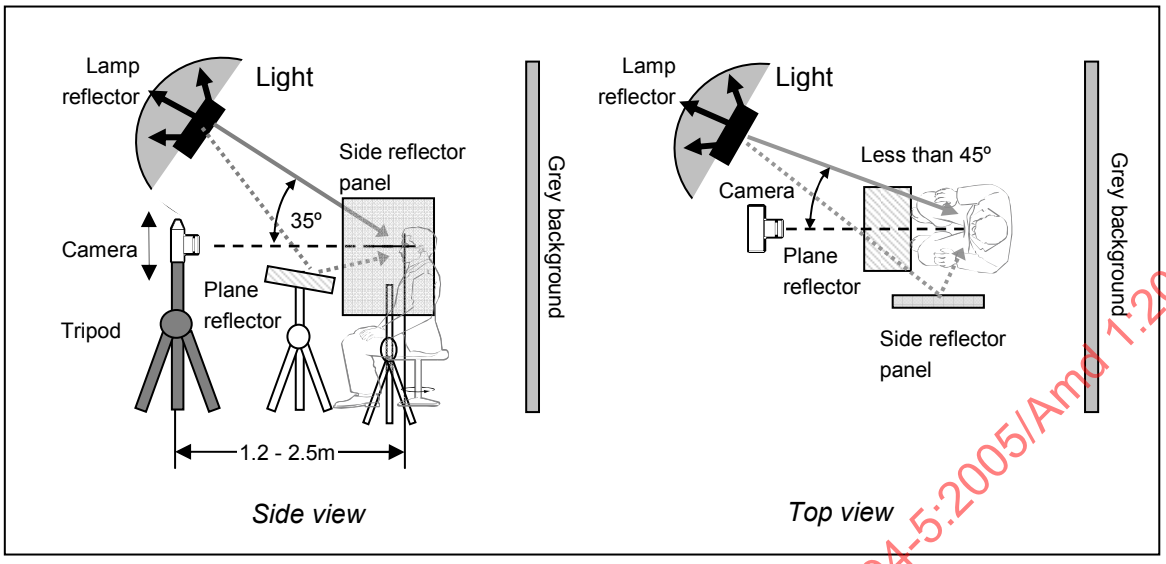


Figure B.4 — Lighting arrangement for a photo studio with a single front light

B.2.1.3.2 Example 2: Proper lighting with dual lights

In the second example illustrated in Figure B.5, two lights are employed. The lights, shown with lamp reflectors, should be placed approximately 35 degrees above the line between the camera lens and the subject. Both lights should be placed within 45 degrees of the line between the camera lens and the subject. Such an arrangement softens the edge of shadows and makes the lighting on the subject more even. The optional plane reflector in front of the subject supplies additional light around and below the subject's chin.

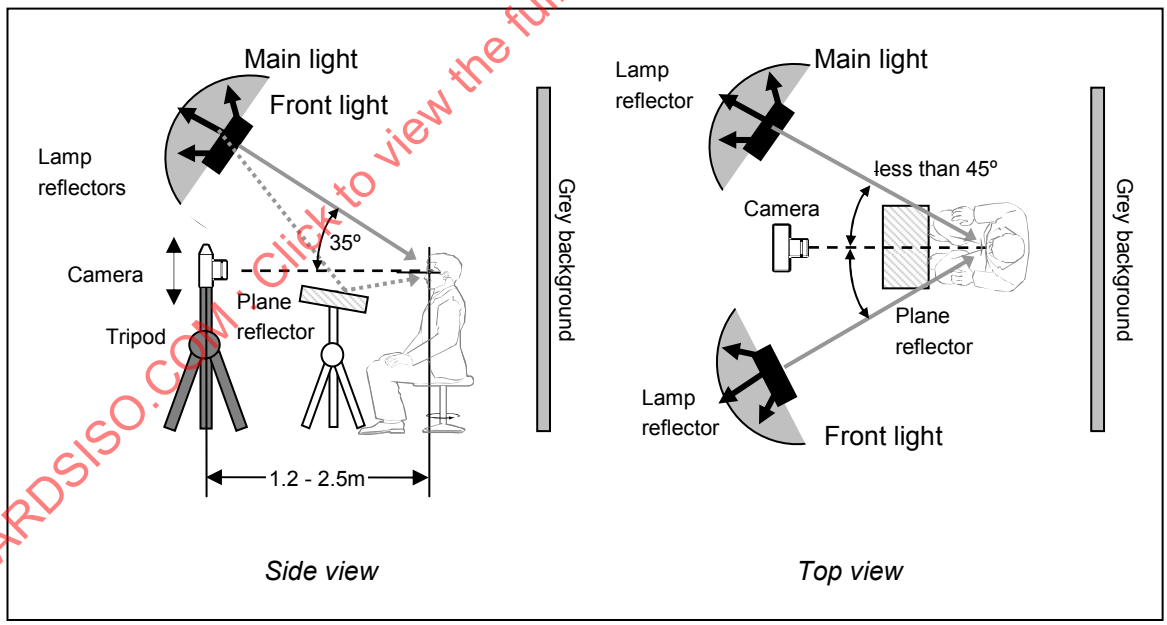


Figure B.5 — Lighting arrangement for a photo studio with dual front lights

B.2.1.3.3 Example 3: Proper lighting with dual lights and background lighting

The use of a background light added to the arrangement shown previously in Example 2 should eliminate shadows visible on the background behind the face. As illustrated in Figure B.6, the background light should be aimed at the background and be placed directly behind and below the subject.

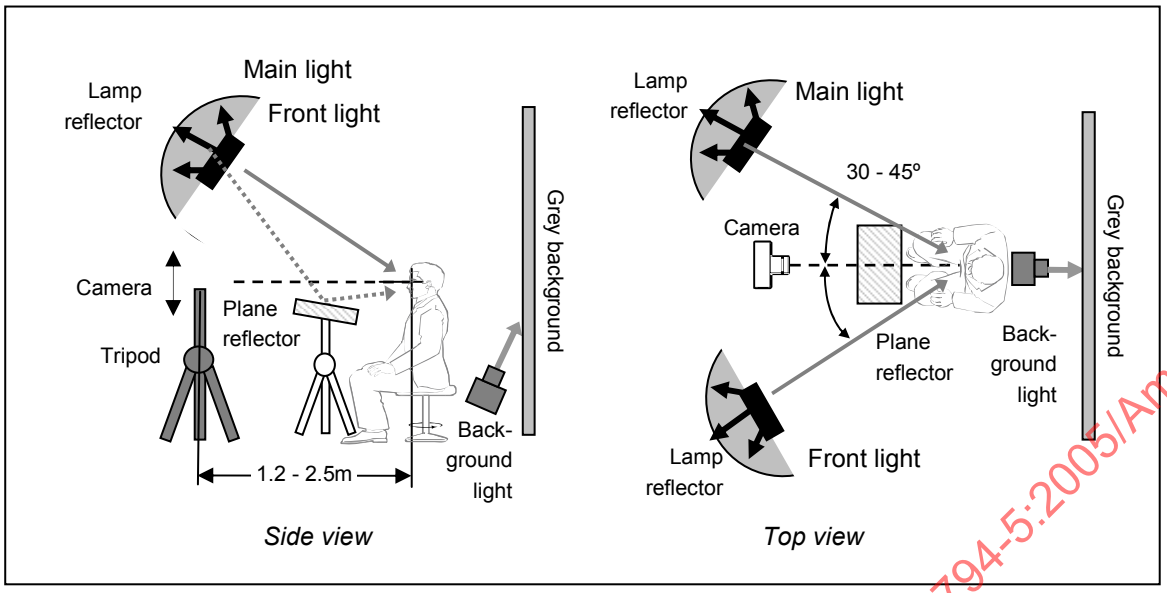


Figure B.6 — Lighting arrangement for a photo studio with dual front lights and a background light

B.2.2 Recommendations for photo booths

A photo booth is typically a coin-operated, self-portrait photography unit, mostly used for taking ID pictures and equipped with such tools as a camera, lighting, stool, plain background, printing device and monitoring screen, and sometimes including an audio self-guidance application. Optimizing photographic technology enabled its space-saving size, which has contributed to its widespread use around the world. Following are some guidelines for the design and operation of such photo booths. Front, side, and top views of the arrangements described in the guidelines are provided. Also provided in this clause are suggestions for camera and subject positioning and a description of methods to provide feedback to the subject concerning his or her pose and expression.

B.2.2.1 Proper lighting

— Position multiple lights behind a diffuser panel and symmetrically above the camera. This will provide even lighting on the subject's face and eliminate most glare and shadow problems. Place a background light low and midway between the background and the subject.

— The placement of the front lights 35 degrees above the line between the camera and the subject's head prevents direct reflection of the flash from a subject's glasses.

— The inside walls should be white, except directly behind the subject. The white walls serve as reflectors and ensure that lighting on the face is uniform horizontally and vertically.

— The interior lights of the booth should be left on during operation. This will usually eliminate red-eye problems associated with photography in dim light.

— To eliminate unwanted shadows around the chin caused by lights above the subject, direct or indirect lighting from below and in front of the subject should be used.

— To ensure that the booth is free from the effects of external light, an opaque curtain should be employed.

B.2.2.2 Example configuration for a photo booth

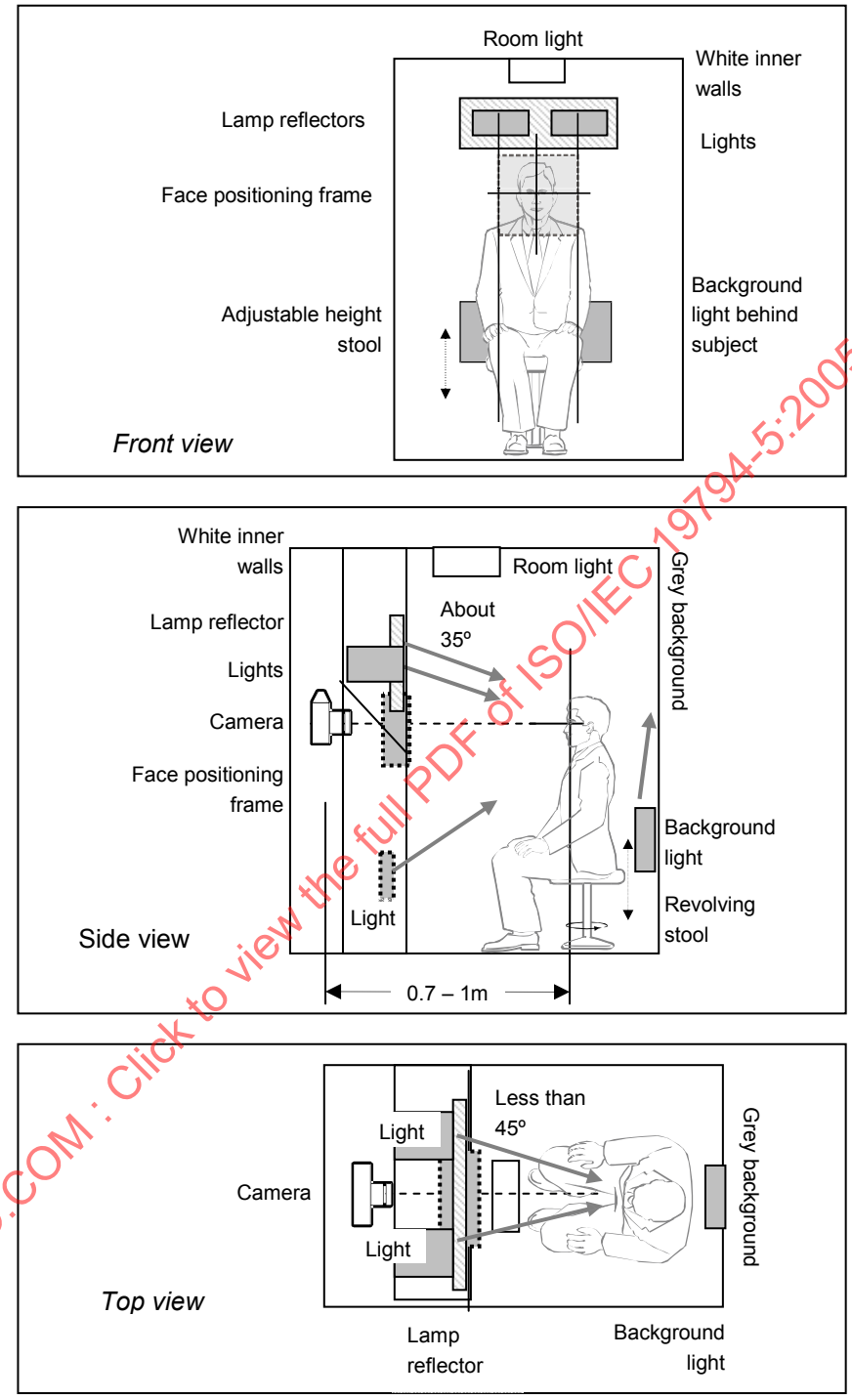


Figure B.7 — Recommended placements of subject, camera, and lights in a photo booth

B.2.2.3 Camera-subject positioning

Proper positioning of the subject and control of the subject's pose can be improved through feedback provided to the subject via a mirror or a live-video monitor.

- A display device should be installed in the booth to provide a live image of the subject on the wall he or she faces. The device could be a one-way (half-silvered) mirror or a left-right reversed live-video monitor. The display should contain a frame which the subject can use to ensure that his/her entire head is fully visible, that his/her eyes are at the correct height, and that his/her face is centered in the camera's field-of-view. Such a frame is illustrated in the following diagram.

- A height-adjustable chair or stool should be provided to allow the subject to face the camera and adjust his eyes to the proper height.

- Camera-to-subject distance is generally within 0.7-1.0 m.

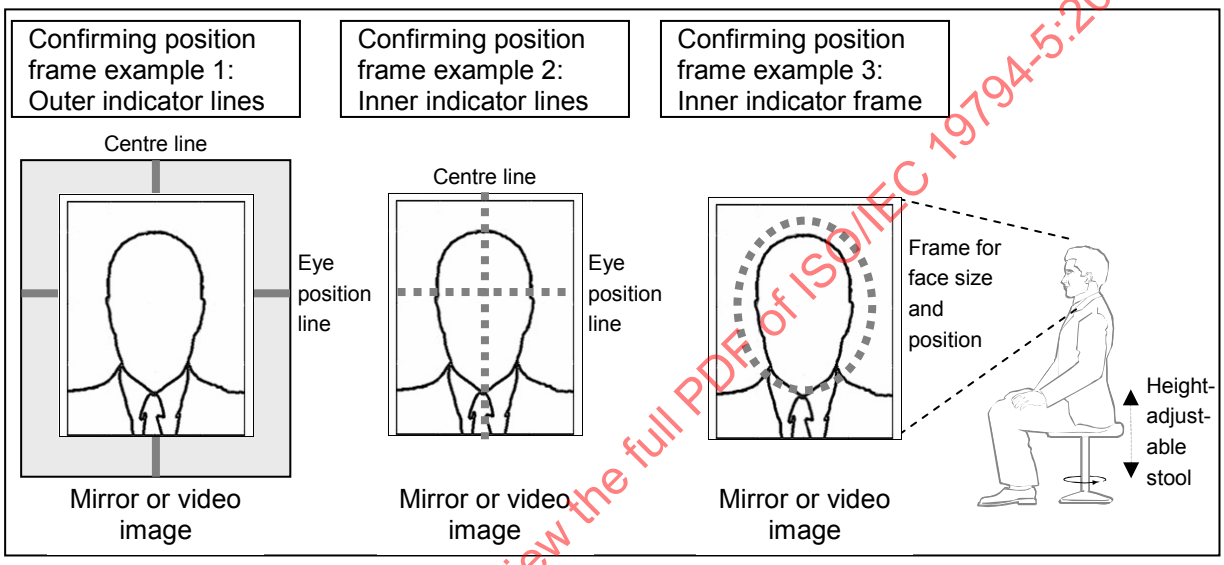


Figure B.8 — Use of a display frame for head positioning

B.2.2.4 Adjustment of size, expression, etc. by monitor-GUI

- An image preview should be provided to allow a subject to recapture the image before it's printed or written to a storage medium, in case a subject might deem his/her pose or expression unacceptable. Illustrations of acceptable poses and expressions should be provided inside the booth.

- The size of the head in the image should be adjustable before printing or storage by allowing the subject to identify the positions of his/her crown and chin in a preview image. The system would then scale and crop the image accordingly. An illustration of such a preview image is provided in figure B.9.

- Alternatively, face detection software that automatically sizes and centers the head within the field-of-view can be used to ensure proper head positioning. Given that such software sometimes does not determine the face position correctly, a preview image should be provided with provision for manual override of the automatically determined position.

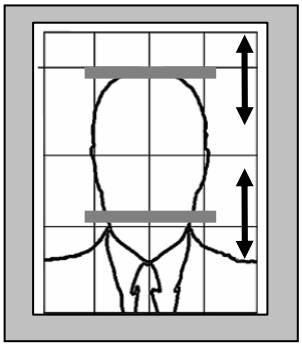


Figure B.9 — Use of movable horizontal lines to set head size

B.2.3 Recommendations for a registration office environment

One of the major application areas of this standard is the use in the context of identity cards and especially Machine Readable Travel Documents (MRTDs). In this domain, images of applicants are either supplied by the applicant or taken in a “live enrolment scenario” in the registration office. For the first case, subclauses B.2.1 and B.2.2 apply. In contrast, this subclause focuses on the recommendations for live enrolment in a registration office environment, where lack of space often is a major concern. Nonetheless, image quality should be as close as possible to that achieved through the recommendations provided previously for the photo studio or photo booth, particularly for MRTDs.

B.2.3.1 Proper lighting

In the best practice arrangement for the Registration Office Environment illustrated in Figure B.10 the subject and the background are illuminated by two diffuse light sources that are mounted in a console with a small footprint, so that it fits into a typical registration office environment. The console can be mounted on the floor or on the wall. Synchronized flash type illumination should be used for these light sources to enable high shutter speed and, thereby, avoid blur caused by a subject's motion. Direct lighting from the sun should be prevented in the office by proper means, e.g., by using curtains or roller blinds.

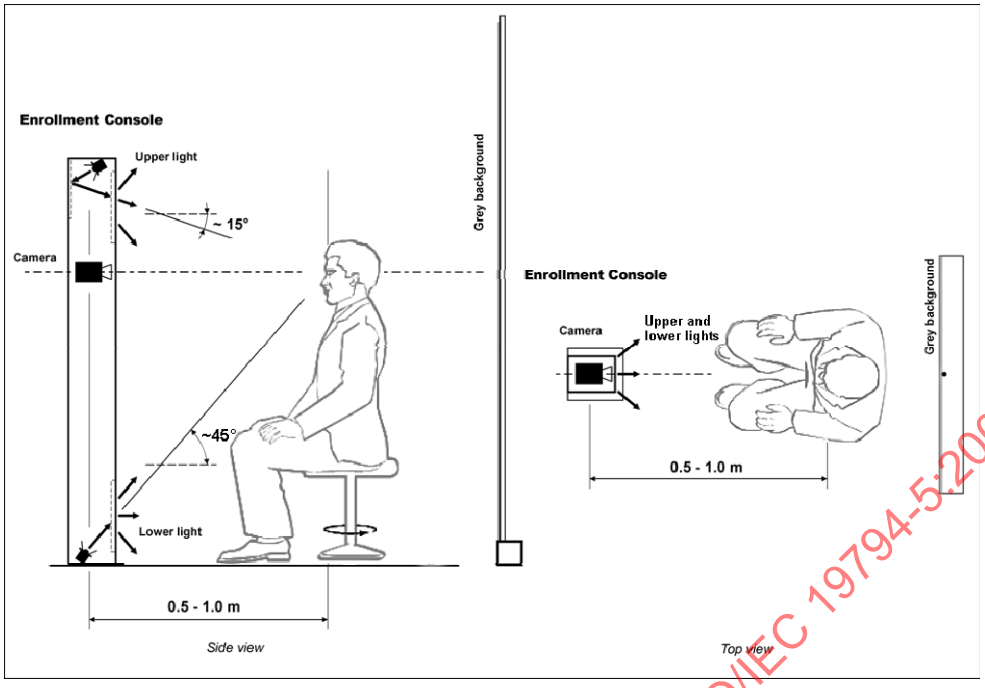


Figure B.10 — Recommended placements of subject, camera, and lights in a registration office environment

B.2.3.2 Camera-subject positioning

- Proper positioning of the subject and control of the subject's pose can be improved through feedback via a second live-video monitor facing to the subject. An image preview should be provided to allow a subject to be recaptured before the image is submitted for further processing, in case a subject might deem his/her expression unacceptable.
- A revolving and height-adjustable chair or stool with an additional cushion for little children should be provided to allow the subject to face the camera and adjust his eyes to the proper height.
- Camera to subject distance is generally within 0.5 to 1.0 meter.

B.2.3.3 Operator support

- Proper positioning of the subject and control of the subject's pose can be improved through feedback to the operator via a live-video monitor showing the face of the subject during the acquisition process. An image preview should be provided to allow the subject to be recaptured before the image is submitted for further processing, in case the operator might deem the pose or expression unacceptable.
- To further improve the process and before the image is further processed, the operator should approve the quality of the image. This can be done with the support of face image quality assessment software, which enables checking the image automatically to ensure it fulfills the requirements of the registration authority or the requirements and best practices provided in this standard. Clause B.5 provides further information on such software and two examples of user interfaces.

B.3 Guidelines for printing

If used for the submission of images to a face recognition system, printing of the images (by either traditional photographic or newer digital techniques) will often be the step between acquisition and recognition that most limits image quality. Thus, it is important that the inherent capabilities of the printing process be used optimally to preserve the maximum amount of information in the image.

Digital printing systems can be broadly categorized into two types: (1) those that are able to control either the density or dot size of ink deposited at each ink dot; and (2) those that can produce ink dots only of a consistent size and density but that can change the frequency of occurrence of the dots. The first category

can be termed continuous-tone printers, the second half-toning printers. If of sufficient resolution, either type may be used to produce prints for scanning and submission to automated face recognition.

B.3.1 Spatial and tonal resolution trade-offs

In any printing method, there is necessarily a trade-off between spatial and tonal resolution (or intensity gradation)—that is, a trade-off exists between the fineness of image details that can be preserved and the smoothness of transitions between pixel levels. Ideally, a process employed for printing face images should not limit either spatial details or tonal gradations to the extent that recognition system accuracy is diminished.

Many countries now expect to receive passport and visa photos that are approximately 50 millimetres square, with a typical distance between the eyes of about 12 millimetres, assuming that face height is somewhat greater than half of the picture height. To provide the 120 pixels between the eyes recommended in Informative Annex A.3, such a photo would require scanning at a spatial sampling frequency of about 12 pixels per millimetre (300 pixels per inch). A halftone printer would need to be capable of printing about 160 dots per millimetre to preserve information at that level of spatial detail with 256 levels of tonal resolution—a level of printing accuracy achievable today only at considerable cost. Clearly, some compromises in spatial or tonal resolution, or both, will be required.

B.3.2 Recommended printing quality

Because the range of available printing technologies is so great, a full set of recommendations covering all potential techniques cannot be provided in this annex. Moreover, even for any one printing technique, the choice of paper can have a substantial effect on image quality. Therefore, the approach taken in the following subclause is not to provide recommendations that are specific to a particular printing technology, but rather to describe the visual appearance of the resulting prints and the minimum quality of digital images resulting from scanning of the prints.

B.3.2.1 Resolution and posterization

Any face printing process should produce a smooth image that is capable of accurately rendering fine facial details, such as wrinkles and moles, as small as one millimetre in diameter on the face. All flesh tones from both light- and dark-complexioned subjects should be printed accurately and no “hot spots” or shadow drop-out should be apparent. Smooth facial details should be rendered without posterization or contouring. Posterization occurs when otherwise smooth details in an image are rendered as an abrupt change in printed colour or density (i.e., as a visible contour).

B.3.2.2 Saturation

With the exception of glare or glints caused by small areas of possible specular (mirror-like) reflection, no portion of the printed image should be saturated in white or black. In other words, no portions of the background or the subject’s garments should be printed fully white and details should be apparent in dark shadow regions.

B.3.2.3 Moiré or visible dot patterns

Digitization of printed photos often introduces artifacts, such as moiré, and certain printing processes can exacerbate the generation of such artifacts. The printing process employed should not produce any noticeable moiré pattern when its prints are scanned with a document scanner at a sampling frequency of 12 pixels per millimetre (300 pixels per inch) or lower in each axis. If a printed photo has been produced through a periodic half-toning process, scanning the photo will almost invariably introduce moiré. Thus, those printers, such as inkjet and laser printers, which inherently employ half-toning to simulate continuous tones, should use non-periodic (or dithered) half-toning methods. Furthermore, the printing process should not produce dot patterns visible to the unaided eye.

B.3.3 Use of a photo template

To facilitate evaluation of printed photographs, it is often useful to provide a transparent template to an acceptance agent or other individual charged with evaluating photo quality. The template would display the limits of head size and rotation (roll) and, when superimposed on the photo, could assist in the determination of whether a submitted photo is compliant with the requirements. An example of such a template, provided by Citizenship and Immigration Canada, along with instructions for its use, is reproduced (at a reduced size) in the figure below.

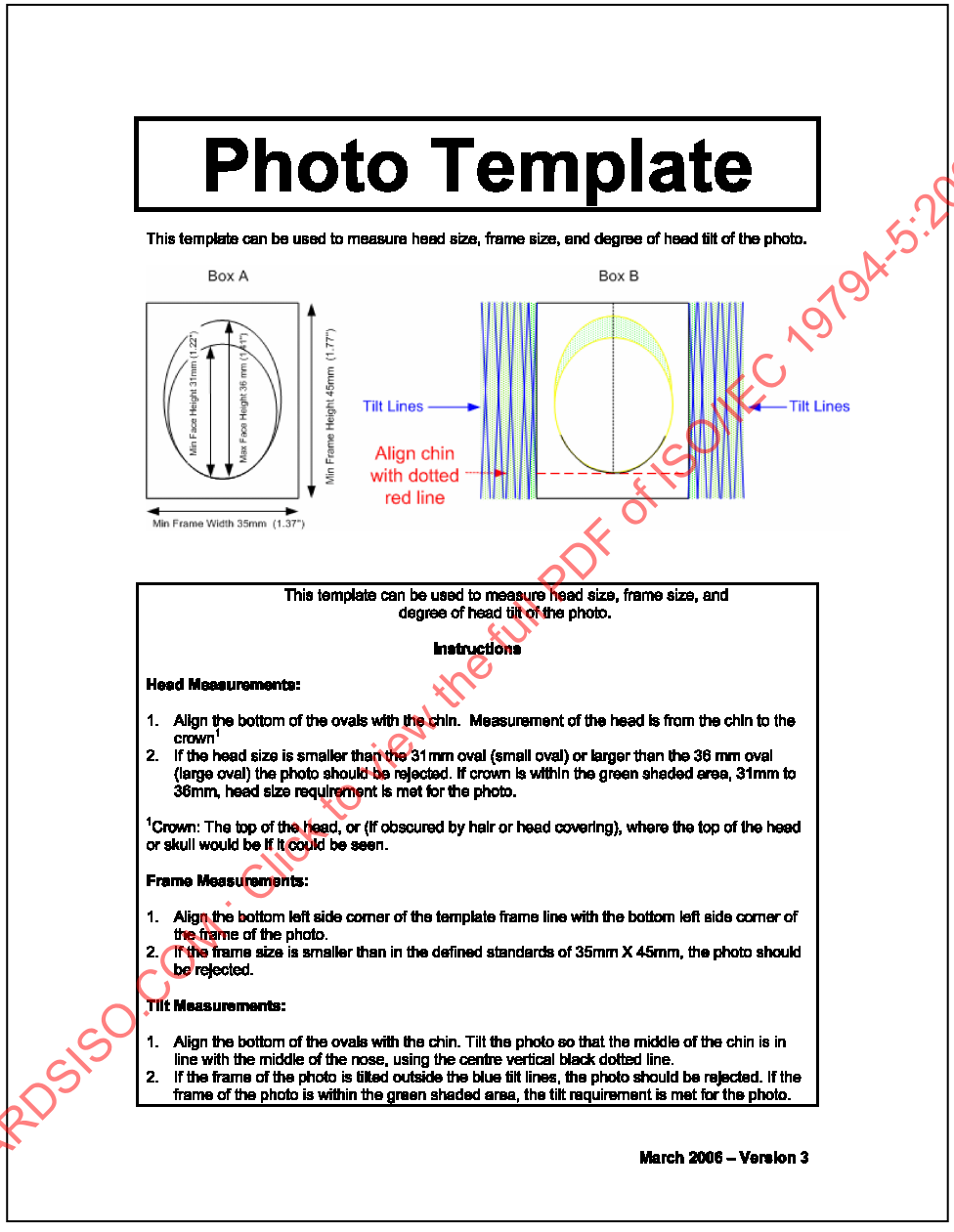


Figure B.12 — Example photo template (provided by Citizenship and Immigration Canada)

B.4 Guidelines for scanning

The intent of these guidelines for scanning is to preserve, to the extent possible, all face-identifying information present in a printed photo when it is converted to a digital image. Preserving the information in a printed colour photo involves sampling it at a sufficient spatial frequency with adequate quantization in at least three spectral regions, usually in the red, green, and blue regions of the spectrum.

B.4.1 Sampling frequency and quantization levels

For a typical passport or visa photo a minimum spatial sampling frequency of about 12 pixels per millimetre (300 pixels per inch) is required to provide about 120 pixels between the eyes. The number of quantization levels should be at least 256 levels per colour, with three colours per pixel.

B.4.2 Spatial resolution

Spatial resolution is a measure of the ability to discern fine detail in an image and, although it's related, it is a metric distinct from sampling frequency. An often used measure of spatial resolution is the modulation transfer function (MTF). To ensure fine facial details are preserved, the scanner's MTF should be at least 20 % at a spatial frequency of 6 cycles per millimetre. Furthermore, the scanner's spatial resolution should be very similar in both axes and should not be enhanced through image sharpening or high-pass filtering algorithms.

B.4.3 Output colour space

Since red-green-blue (RGB) colour space and its derivatives are inherently device-dependent, the scanner's output should be converted to a well-defined, device-independent colour space such as *sRGB*. Alternatively, an International Colour Consortium (ICC) standard-compliant colour profile for the scanner's native space can be embedded within the output image file.

B.4.4 Saturation

Saturation occurs when significant numbers of pixels have values that are at the limits of quantization, i.e., at the levels of 0 or 255, if quantization of eight bits per colour is employed. Acceptable scanned face images should not have a significant number of pixels in saturation.

B.4.5 Image compression

To reduce scanned image files to manageable sizes, lossy image compression with JPEG or JPEG2000 is typically used in document and film scanners. For some scanners, the manufacturer or software designer has incorporated a single or limited number of image quality-compression ratio trade-off points that a user may choose. The selection of overly high compression may substantially reduce image quality and, hence, diminish the accuracy of face recognition, as described in subclause A.3.3 of Informative Annex A of this standard. Therefore, a user must be cognizant of the available image quality alternatives offered by the scanning system and the consequences of selecting certain quality-size trade-off points. If storage space or transmission time for the generated images is not overly limited, an alternative offering high image quality and, hence, large file size is an appropriate choice to ensure best possible recognition accuracy.

B.5 Face image quality assessment software

Several products, in the form of software development kits, which attempt to measure the compliance of submitted face images with various requirements described in the body of this standard, have become available commercially. Typically, these products provide multiple measures of face image quality, as well as a single, combined overall quality and can determine automatically whether submitted face images are likely to be of adequate quality for a particular application. Some of the metrics which have been incorporated into these products include face size, face centering, contrast, focus, background texture or uniformity, lighting uniformity, and head rotation (yaw and roll). Ideally, these metrics will correlate well with human perceptions of quality or with automated face matcher performance and will be thresholdable at user-defined settings. Face image quality assessment software may be a useful adjunct to human assessments of quality in photo studios, photo booths, or registration office environments. Examples of the graphical user interfaces (GUIs) for two such products are shown in the following figure.

Figure B.13 — Two sample GUIs of face image quality assessment software

B.6 Tables of the recommendations

Most of the recommendations for scene setting, photographing, after photographing and photographic quality are summarized in the following tables. In these tables, the Contents column contains references to the relevant sections of this standard. The **PS** and **PB numbers** relate to the similarly labeled photo studio and photo booth examples provided in Clause B.7, Photographic Examples.

B.6.1 Scene setting

Table B.1 — Scene setting Recommendations

Category	Contents	Photo studio	Photo booth	Registration office
Lighting	Number of lights (ref. 7.2.10 Hot spots)	Use 2 or more lights, if possible. When a single light is used, employ reflectors to redirect the light. Background lighting is recommended to reduce shadows. **(PS1)**	Use 2 or more lights, if possible. When single light is used, white walls that can serve as reflectors are recommended. Background lighting is recommended to reduce shadows. **(PB1)**	Use 2 or more lights. If possible, background lighting is recommended to reduce shadows on background.
	Lighting methods (ref. 7.2.10 Hot spots)	Provide diffuse illumination by using lamp reflectors (ex. bounce umbrella), lamp diffusers(ex. soft box strobe), reflector panels, etc. **(PS2)(PS3)**	Provide diffuse light using lamp reflectors or a white translucent plastic panel. White walls can also serve as reflectors. **(PB2)(PB3)**	Provide diffuse light using white translucent plastic panel for down and up light.
	Colour temperature	4500 – 6500K is recommended.	4500 – 6500K is recommended. Hold colour balance using grey or white walls. Eliminate stray or outdoor light with a curtain or door.	4500K – 6500K is recommended. Hold colour balance using grey or white background. Minimize outdoor light by using appropriate means (e.g. curtains).
	Guide Number of strobe	Recommended Guide Number is over 7 for external flash, 14 for built-in flash. (photographic distance of 1.2 – 2.5 m) The built-in flash in compact cameras is not recommended because the Guide Number is typically only about 10, so it is insufficient, and it produces bad lighting (e.g, shadows on the background and red-eye)	Guide Number should be over 7. (photographic distance of 0.7 – 1.0 m)	Guide Number should be over 10 (photographic distance of 0.5 – 1.0 m). Use two balanced strobes.
	Lighting Uniformity (ref. 7.2.7 Subject and scene lighting)	Lighting should be evenly distributed. The difference of four exposure values on the left and right sides of a face, chin and forehead should be less than 1 EV. **(PS4)**	Lighting should be evenly distributed. The difference of four exposure values on the left and right sides of a face, chin and forehead should be less than 1 EV. **(PB4)**	Lighting should be well balanced. The difference of four exposure values on the left and right sides of the face, chin and forehead should be less than 1 EV.
	Light arrangement	30 – 45 degrees of subject-lens axis. 35 degree elevation angle for subject-light line. **(PS5)**	Symmetrical position. 30 – 45 degrees to subject-lens axis. 35 degree elevation angle for subject-light line. **(PB5)**	Above and under the subject-lens axis. Typically 15° degrees from above and 45° degrees from below.

Category	Contents	Photo studio	Photo booth	Registration office
Subject	Pose angle less than +/- 5 degrees) (ref. 7.2.2 Pose)	Provide simple guidance to the subject concerning the proper pose. Position camera horizontally on the centre line of the face, vertically between the eyes and the tip of the nose. Camera height adjustment may be done with the tripod. **(PS6)**	Guide the proper position of the face for the subject. Position camera horizontally on the centre line of the face, vertically between the eyes and the tip of the nose. The height adjustment can be done with a revolving stool for the subject. The subject can also check the proper position by a mirror in front of him/her or by a preview image provided before or after image capture. Expression guidance is recommended to place on elsewhere of photo booth. **(PB6)**	Provide simple guidance to the subject concerning the proper pose. Camera position meets horizontally right at the centre line of the face, vertically between eyes and the tip of the nose. The height adjustment can be done with a revolving stool for the subject and an additional cushion for small children. The operator as well as the subject can check proper position on (a) preview monitor(s) if provided.
	Shoulder positioning (square on to the camera) (ref. 7.2.5 Shoulders)	Give the subject advice. **(PS7)**	The subject can also check the proper position by the mirror in the front of him/her or the image shown before/after the shoot. Indicate the suggested position of shoulders on the inner wall in front of the subject. The photograph can be retaken in case it is unacceptable. **(PB7)**	Give the subject advice. The operator as well as the subject can also check the proper position of him/her or the image shown before/after the shoot in case a preview is provided. The photograph can be retaken in case it's unacceptable.
	Face size adjustment	In case of no size adjustment after photographing, face size or face position (crown and chin) should be confirmed before photographing on the screen of camera. The adjustment can be made by, if needed, adjustment of (1) distance between a subject and camera or zoom magnification for face size and (2) height and position of camera for face position.	In case of no size adjustment after photographing, face size or face position (crown and chin) should be confirmed by the subject before photographing on the monitor or a mirror which is equipped. The adjustment can be made by, if needed, adjustment of (1) zoom magnification for face size and (2) height of a stool or a chair for face position.	Face size or face position (crown and chin) should be confirmed on the operator preview and especially on the output of the quality assessment software presented to the operator. If needed, the adjustment can be made by the distance of the subject and the camera or the zoom magnification handled by the operator for face size. For the vertical position a necessary adjustment is done by the revolving stool.
	Recommended Expression (Neutral, non-smiling, with both eyes open and mouth closed) (ref. 7.2.3, A.2.2 Expression)	Give the subject some advice. **(PS8)**	The subject can also check the proper expression by the mirror in the front of him/her or the video image shown before/after photographing. The photograph can be retaken in case it is unacceptable. **(PB8)**	Give the subject some advice. The operator as well as the subject can check proper expression on the preview monitor if provided. The photograph can be retaken in case it' s unacceptable.
	Eye glasses (Acceptable when: Normal use, Permanently tinted for medical reason, Frames do not obscure the eyes) (ref. 7.2.11 Eye glasses)	Give the subject some advice. Adjust the angle between the light and the subject to reduce glare. **(PS9)**	The subject can also check the glare by the mirror in the front of him/her or the image shown before/after the shoot. The photograph can be retaken in case it is unacceptable. **(PB9)**	Give the subject some advice. The operator as well as the subject can check the glare the preview monitor if provided. The photograph can be retaken in case it's unacceptable.
Background	Background colour (ref. A.2.4.4 Background examples)	Grey, light blue, white, off-white	Grey, white, off-white	Grey, light blue, white, off-white

Category	Contents	Photo studio	Photo booth	Registration office
	Background uniformity (ref. A.2.4.3 Background uniformity)	Plain. A uniform or a single colour pattern with gradual change caused by background light	Plain. A uniform or a single colour pattern with gradual change caused by background light	Plain

B.6.2 Photographing

Table B.2 — Photographing recommendations

Category	Contents	Photo studio	Photo booth	Registration office
Camera set-up	Shutter speed	Shutter speed (1/60-1/250) should be fast enough to prevent motion blur, unless electronic flash is the predominant source of illumination. Camera should be fixed with a device such as a tripod or rigid stand. **(PS10)**	Shutter speed (1/60-1/250) should be fast enough to prevent motion blur, unless electronic flash is the predominant source of illumination.	Shutter speed (1/60-1/250) should be fast enough to prevent motion blur, unless electronic flash is the predominant source of illumination.
	White balance (ref. A.2.7 Colour calibration)	Manual correction. Set up with the colour of grey in order to check the proper white balance. **(PS11)**	Manual correction at the time of Photo Booth installation or maintenance. Set up with the colour of grey in order to check for proper white balance.	Automatic correction before shooting.
	Over or under exposure (ref. 7.3.2 No over or under exposure)	Check with an exposure meter. Use 18% grey test chart for the proper adjustment of exposure. **(PS12)**	Correct exposure while setting system. Use an 18% grey test chart for the proper adjustment of exposure.	Correct exposure while setting up system. Use an 18% grey test chart for the proper adjustment of exposure.
	Camera-to-subject distance (ref. A.2.8 Radial distortion of the camera lens)	1.2 – 2.5 m in a typical photo studio **(PS13)**	0.7 – 1.0 m in a typical photo booth **(PB10)**	0.5 – 1.0 m in a typical registration office scenario
	Focal length of camera lens (35 mm format equivalent) (ref. A.2.8 Radial distortion of the camera lens)	A normal to a medium telephoto lens (50 – 130 mm) (Shooting distance of 1.2 – 2.5 m)	A normal to medium telephoto lens (40 – 100 mm) (Shooting distance of 0.7 – 1.0 m)	A light wide angle to medium telephoto lens (36 mm – 100 mm) (Shooting distance of 0.5 – 1.0 m)
	Resolution (ref. 7.3.3 Focus and depth of field)	Higher than 2 pixels per mm (Can be checked by test shooting a ruler)	Higher than 2 pixels per mm (Can be checked by test shooting a ruler)	Higher than 2 pixels per mm (Can be checked by test shooting a ruler)
	Face size adjustment (ref. 8.3 Photographic requirements for the Full Frontal Face Image Type)	Face position marks, indicated by feature points or bars at the positions of the subject's crown and chin bottom, should be visible in the camera's viewfinder screen. This allows the photographer to ensure that distance and zoom are correct before shooting.	A mirror or a live-video monitor that displays face position marks, indicated by feature points or bars at the positions of the crown and chin bottom, could be used. This will enable a subject to fit his face within the image properly and to make any needed adjustments, such as zoom lens magnification, before shooting.	A live-video monitor that displays face position marks, indicated by feature points or bars at the positions of the crown and chin bottom, could be used. This will enable the operator to make any needed adjustments, such as zoom lens magnification, before shooting.

B.6.3 After photographing

Table B.3 — Printing and scanning recommendations

Category	Contents	Photo studio	Photo booth
Printing	Colour and density	Teeth and whites of eyes shall be clearly light or white and dark hair shall be clearly dark.	Teeth and whites of eyes shall be clearly light or white and dark hair shall be clearly dark.
	Resolution	Photographs should have a life-like quality. Resolution shall be sufficient to resolve facial details less than 1 millimetre in diameter.	Photographs should have a life-like quality. Resolution shall be sufficient to resolve facial details less than 1 millimetre in diameter.
	Size adjustment of face	Digital: Use application software to specify the position of the crown and chin. Analogue: Adjust zoom magnification mode while printing.	Digital: The position of crown and chin can be specified on the monitor. Analogue: Adjust zoom magnification mode before shooting.
Scanning	Colour and density (ref. 7.3.5 Colour or greyscale enhancement, 7.4.2.3 colour space)	Teeth and whites of eyes shall be clearly light or white and dark hair shall be clearly dark. 24 bit-RGB. Use a device-independent colour space or embed the device's colour profile. Retouching should not be done.	
	Resolution (ref. A.3.1.1 Photo Resolution)	About 12 pixels per millimetre (300 ppi).	
	Cropping (ref. 7.4.1.1 Pixel aspect ratio)	Pixel aspect ratio of 1:1 should be maintained.	
	Size adjustment of face image (ref. 8.3 Photographic requirements for the Full Frontal Face Image Type, A.3.2 Best practice for use of Full Frontal Images on travel document)	When necessary, use only bi-linear or bi-cubic methods or other superior resampling algorithms to resize or rotate the face image. Resampling should only be performed to decrease the image's pixel dimensions, not to increase them.	

Category	Contents	Registration office
Printing and Scanning		Not Applicable, as live enrolment is done to avoid a breech in the digital production chain. Document printing on the ID document (e.g. passports, ID cards, driver's licenses, etc.) is driven by security requirements on the final document and the technology suited for fulfilling these requirements (e.g. laser engraving, etc.)
Quality Assessment	Geometric requirements	The quality assessment software should check if the image and the head shown in the image (after cropping) meet the geometric requirements imposed by this standard and the requirements imposed by the registration authority. Inter-eye distance and positioning of the head are prominent examples that should be checked automatically.
	Constraints on the subject	The quality assessment software should check if the image meets the requirements imposed on the subject (e.g., pose) by this standard and the requirements imposed by the registration authority.
	Constraints on the scene	The quality assessment software should check if the image meets the requirements regarding the scene composition (e.g., background colour) imposed by this standard and the requirements imposed by the registration authority.
	Constraints on the photographic requirements	The quality assessment software should check if the image meets the requirements regarding the photographic requirements (e.g., absence of blur) imposed by this standard and the requirements imposed by the registration authority.

B.6.4 Photographic quality

Table B.4 — Photographic quality recommendations

Category	Contents	Photo studio	Photo booth
Photographic quality	Evenness of illumination (ref. 7.2.10 Hot spot)	a) The difference of four Exposure Values on the left and right sides of a face, the chin, and forehead should be less than 1EV. **(PS4)** b) Light source should be diffused by using reflectors such as bounce umbrellas or reflective panels. Direct light should be dispersed in multiple directions. **(PS2)** c) Calibrate the correct exposure using an exposure meter. Do not allow over exposure.	a) The difference of four Exposure Values on the left and right sides of a face, the chin, and forehead should be less than 1EV. **(PB4)** b) Light source should be diffused by a diffuser panel or white walls serving as reflectors. Direct light from the front should be dispersed in multiple directions. **(PB2)** c) Do not allow over exposure.
	Shadows over the face (ref. 7.2.8 Shadows over the face)	a) It is preferable to direct the main light toward the subject's face at a horizontal angle of less than 45 degrees. **(PS5)** b) If there's any shadow, place a reflector panel in front of the shadow so that the light is bounced off its reflective surface to lighten the shadow and soften contrast. c) The difference between Exposure values of left and right sides of a face, or chin and forehead should be less than 1EV. **(PS1) (PS4)**	a) It is preferable to direct the main light toward the subject's face at a horizontal angle of less than 45 degrees from the camera to subject axis. Should use more than 2 lights. b) The difference of Exposure values between left and right sides of a face, or chin and forehead should be less than 1EV.
	Background shadows (ref. A.2.4.2 Background shadows)	Use a background light to eliminate shadows visible on the background behind the subject.	Use a background light to eliminate shadows visible on the background behind the subject. White walls will reflect some of the light and lighten the shadows..
	Glare on glasses (ref. 7.2.11 Eye glasses)	Direct the light toward the subject at a vertical angle of more than 35 degrees. This will reduce the glare. **(PS9)**	Direct the light toward the subject at a vertical angle of more than 35 degrees. This will reduce the glare. The subject can check the proper position by the mirror in the front of him/her or a video image shown before or after photography. The photograph can be retaken in case it's considered unacceptable. **(PB9)**

B.7 Experimental data

B.7.1 Experimental results of face recognition in a photo studio and photo booth

Face recognition experiments were performed under several ideal and actual lighting conditions, including down lighting at airports that cast strong shadows on faces. The experiments were performed in Japan and supported by the Japanese Ministry of Foreign Affairs, with the participation of several face recognition vendors. The experiments were done under the practical requirements specified in this standard, such as object conditions (pose, expression, glasses, etc.), photographic equipment (camera, lighting, background, etc.) and other aspects in four different lighting conditions: best practice, bad airport lighting, improved lighting at airport, and photo booth.

The total number of the subjects photographed was approximately 160. The images were taken under the conditions listed in Table B.5, with the passport photo width-to-height ratio of 1:1.29 and pixel dimensions of 420 × 540, which is the size typically used by the Japanese Ministry of Foreign Affairs. The images used in these tests were compressed to an average size of 80k bytes using JPEG compression. For each lighting condition tested, all images were compared to the best practice images in one-to-many (i.e., Identification) testing, using several face recognition products. The performance metric measured was the Cumulative Match Rate (CMR) at Rank 1.

Table B.5 — Lighting arrangements of photographing conditions

Lighting conditions	Lighting	Photographing equipment	Shooting distance
Best practice	Front lighting from three directions (Diffused flash light sources) with a reflector panel placed under a subject's chin	Single-lens reflex (SLR) digital still camera f = 60 mm (f = 35-70 mm zoom lens)	2.4 m
Bad airport lighting (dark lighting and shadowed)	Overhead down lighting, ordinary light source, no reflector panels	SLR digital still camera f = 60 mm (f =3 5-70 mm zoom lens)	1.7 m
Improved lighting at airport	Single-point front lighting and overhead down lighting, ordinary light source, no reflector panels	SLR digital still camera f = 60 mm (f = 35-70 mm zoom lens)	1.7 m
Photo booth	Multiple lighting sources, from at least three directions, including indirect light source (diffused flash light source), and one background lighting	Fixed-focal-length digital still camera (f = 40 mm)	0.7 m

Following are the results from the experiment, which are also summarized in Table B.6:

— In the comparison between best practice lighting and airport lighting, the CMR for typically bad airport lighting was fairly low: 40 – 80 %.

— To improve face recognition accuracy, lighting arrangements to reduce excessive shading on the face (i.e., improved lighting at airport) worked effectively.

— No significant difference in the CMR was found between the results for best practice and photo booth.

Table B.6 — Comparison of results of face recognition accuracy for various lighting conditions

Lighting conditions enrolled image vs. query image	Cumulative Match Rate (%)
Best practice vs. bad airport lighting (insufficient intensity and shadowing)	40 – 80
Best practice vs. improved lighting at airport	Approx. 100
Best practice vs. photo booth	100

Note Cumulative Match Rate (CMR) refers to the Rank 1 match rate. The statistical uncertainty in the measured face recognition accuracy rates was approximately 3 %. Uncertainty refers to B.1.1 Rule of 3 in ISO/IEC 19795-1.

B.8 Photographic examples

To illustrate and explain the recommendations provided in the tables of Clause B.6, the following photographic examples were taken under various conditions in a photo studio and a photo booth. Preceding the examples are brief descriptions of the recommended conditions for a photo studio or photo booth and the specific camera settings chosen.

B.8.1 Photographic examples at a photo studio

a) Recommended photographic conditions at a photo studio

Table B.7 — Recommended photographic conditions at a photo studio

Category	Lighting	Subject	Background	Camera conditions
Photo-studio (See 2.1 Recommen-dations for a Photo Studio or Store)	Two lights, each diffused with a lamp reflector, single background light. Lights symmetrically arranged at 45° from camera-to-subject line. The angle of elevation is 35°. ΔEV = 0.2. (Horizontally 0.2 EV, vertically 0.2 EV), Front reflector, Colour temperature is 5200K.	The photographer should provide instructions to the subject. For positioning adjustment, use a guide frame on the preview screen of the camera. Height adjustment by tripod or stool. Camera-to-subject distance is 1.5 m.	Grey	Manual, F11, 1/125 sec., f = 75 mm, measurement with exposure meter and colour temperature meter (f: equivalent focal length for 35 mm film camera)

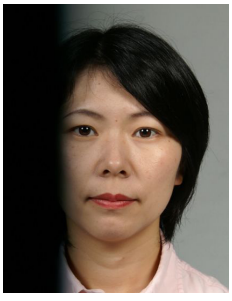
b) Photographic examples at a photo studio

[NR]: Not recommended – image obtained under not recommended conditions.

Category	Item	Photographic examples		
Lighting	Number of lights **(PS1)**	ΔEV=0.2 		ΔEV=1.5 
		Two lights and background light	Single light and side reflector panel	Single light (without side reflector panel) [NR]
	Diffuse illumination **(PS2)**			
		Lamp reflector	Without lamp reflector [NR]	Camera strobe light [NR]

Category	Item	Photographic examples		
	Reflector panel **(PS3)**			
		Front reflector panel, two lights	Without reflector panel, two lights	
	Lighting uniformity (Exposure value difference between right and left) **(PS4)**			
		ΔEV=0.2	ΔEV=0.5	ΔEV=0.8
	Light arrangements **(PS5)**			
		Symmetrically 45°	left 75°, right 45° [NR]	
				
		Angle of elevation: 35°	Angle of elevation: 70° [NR]	

Category	Item	Photographic examples		
				
		Angle of elevation: 35°	Angle of elevation: 0°, glare on glasses [NR]	
Subject	Pose angle **(PS6)**			
		Camera height adjustment	Without camera height adjustment [NR]	
				
		With instruction	Tilting the bridge of the nose [NR]	Incorrect face direction (gaze to the right) [NR]
	Shoulder positioning **(PS7)**			
		Square on to the camera	Not square on to the camera [NR]	

Category	Item	Photographic examples		
	Expression **(PS8)**			
		With instruction	Without instruction (wrong eye direction) [NR]	
				
		With instruction	Without instruction (smile) [NR]	
	Glare on glasses **(PS9)**			
		Tilting her head forward	Without tilting her head forward (Note glare on glasses) [NR]	
Camera conditions	Shutter speed **(PS10)**			
		1/125 sec.	1/300 sec. (poor synchronization) [NR]	